Super Pape Airplanes

Biplanes to Space Pl

Norman Schmidt

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The advice and directions given in this book have been carefully checked, prior to printing, by the Author as well as the Publisher. Nevertheless, no guarantee can be given as to project outcome due to possible differences in material and the Author and Publisher will not be responsible for the results.

Flight

People have been obsessed with the idea of flight ever since they looked into the sky and saw birds soaring gently overhead. Mythical stories in many cultures around the world have flying creatures of all sorts, including human beings. When did the reality of human flight begin?

Archeologists in Egypt have discovered a small wooden bird, carved from lightweight sycamore wood, that has a very aerodynamic shape. This small wooden bird is unlike any real bird because its tail has both horizontal and vertical surfaces, just like present-day airplanes. It is not known whether this was a toy, a weather vane, or a small model of some larger craft.

There are other examples of flying toys, such as the Saqqara bird invented by the Greek philosopher Archytas in about 345 B.C. It was a small wooden dove attached to an arm that allowed it to "lift off" in wavering flight. It is not known how the bird was propelled. At about the same time the Chinese philosopher Mo Tzu constructed what was possibly the first kite, which is simply a tethered airplane. Some Europeans made wings of wood, cloth, and bird feathers, strapped them to their arms, and jumped off high buildings. In 1020 Eilmer "the flying monk" did this, and attained some success with flight, but broke both his legs in the attempt. In the 1500s the artist and inventor, Leonardo da Vinci, made many drawings and models of different kinds of aircraft, including the parachute. Another story from the 1700s tells of a French locksmith named Besnier, who, with wings strapped to his arms and legs, jumped from a tall building and glided over neighboring houses.

The development of kites continued and they became the forerunners of free-flying airplanes. European inventors and scientists used them to carry out experiments in aerodynamic forces. Such experiments led to the first free-flying airplanes of Sir George Cayley in the 1790s. They demonstrated the principles of flight as they are understood today. In the 1850s Sir George's coachman was among the first people to fly in an actual airplane. The stage was now set for the development of controllable airplanes. That story is told through the paper airplanes that follow in this book.

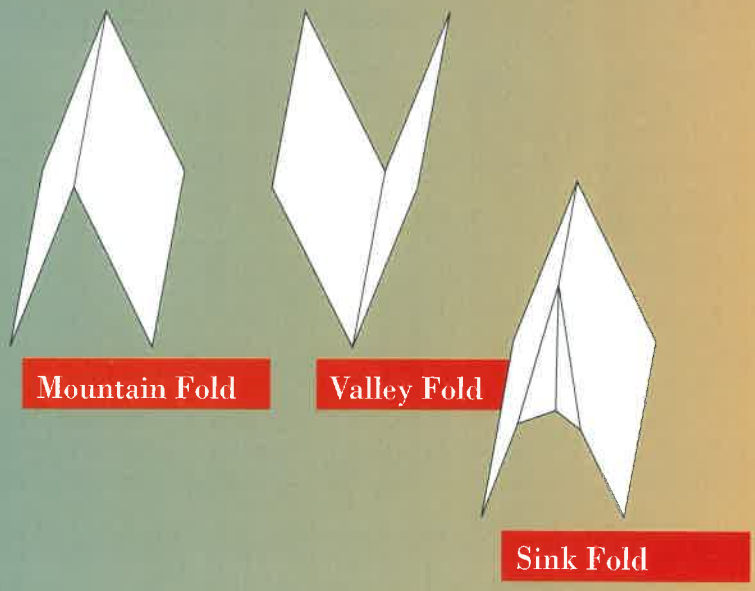
onstruction

n carefully made, the paper airplanes is book are super flyers. They can be using ordinary 20 or 24 lb bond copier r measuring 8-1/2 in by 11 in (21.6cm 7.9cm). Bond paper is lightweight, easy t and fold, and easy to fasten together. available in a variety of colors (black r may have to be purchased from an art). Since a paper airplane's lift and st are limited, every effort must be made ep drag at a minimum. Every surface arallel to the direction of travel (wings, , and canopy) adds drag, so the neater more accurate your construction, the r the plane will fly. Clean and accurate and crisp folds are a top priority.

suring and Cutting Use a sharp pencil ark the measurements and draw firm, rate lines. Cut out the pieces with a p pair of scissors or a craft knife and a -edged ruler. A knife makes a cleaner When using a knife be sure to work on per cutting surface.

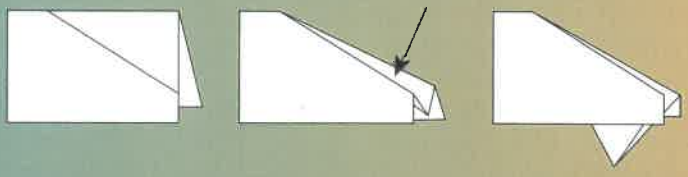
ing Always lay the paper on a level ace for folding. Folding is easier along a e line (an indented line on the paper e with a hard pencil drawn along a). There are only three kinds of folds in making the airplanes in this book. are mountain folds, valley folds, and folds. Where multiple layers are folded, your fingers back and forth along the pressing hard to make a sharp crease.

ng A glue stick works well for paper anes. Follow the instructions for gluing. r the entire contacting surfaces that are joined. If there are multiple layers, y glue to each of the sheets. Glue should sed sparingly, but use enough to hold arts together. Where multiple layers eing joined you may need to hold the s for a few minutes until the glue sets.



A mountain fold and a valley fold are actually the same kind of fold. Both are made by folding a flat piece of paper and sharply creasing the fold line. The only difference is that one folds up (valley fold) and the other folds down (mountain fold). They are distinguished only for convenience in giving instructions.

To make a sink fold, begin with paper that has been folded using a mountain (or valley) fold and measure as required across the folded corner. Then push in the corner along the measured lines, making a diagonal fold. Finish by creasing the folds sharply.



Trimming for Flight

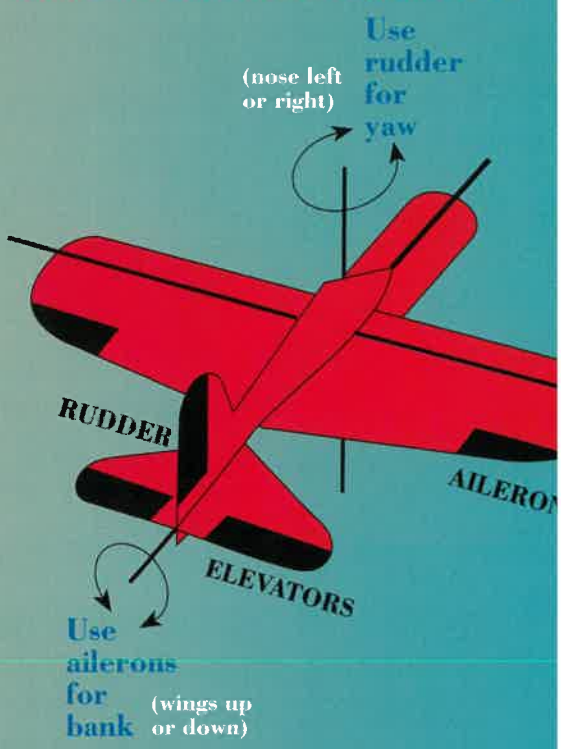
Air is made up of small, solid, evenly spaced particles called molecules.Everything in the universe is made up of molecules, but air molecules are quite far apart compared to those that make up metal, wood, or paper, and they are easily separated when a body moves through them. The molecules are piled up in a thick layer from the ground, and this is called the atmosphere. It forms part of the space around us and the sky above us. This layer of air molecules (atmosphere) exerts pressure on everything in the world and it is this pressure that makes flight possible. The shape of the airplane affects the molecules as they move across the airplane's surfaces, increasing or decreasing air pressure, determining the flight characteristics of the plane.

No paper airplanes are perfectly straight. And they are easily bent. Shown right below is an example of trimming using the rudder. Airplane A flies straight because air flows smoothly along its surfaces. It needs no trim. Airplane B yaws to the left because the air on the left is deflected by the bent fuselage, increasing air pressure on that side. The rudder is used to compensate. Airplane C again flies straight because it has been trimmed so that the deflected air on the left is opposed by air being deflected by the rudder on the right. But airplane C does not fly as well as airplane A because it is creating much more drag.

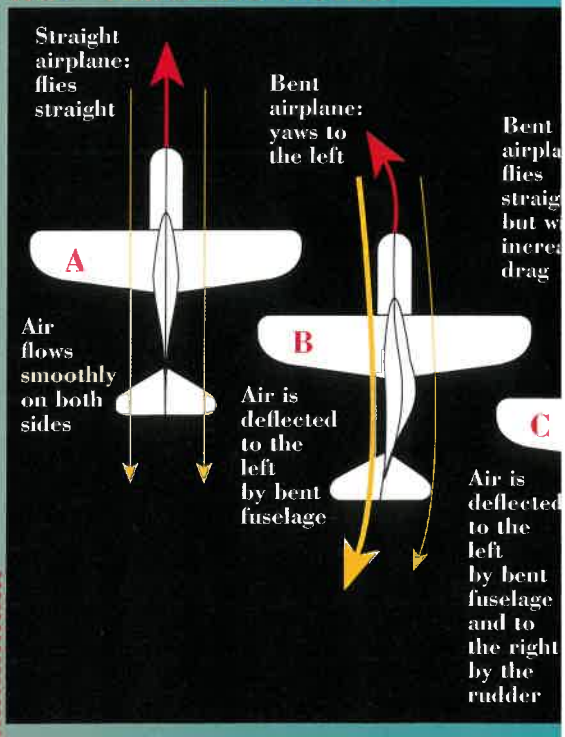
Before making any trim adjustments to a paper airplane that you have just constructed, be sure you are releasing the plane correctly for flight. Always begin with a gentle straight-ahead release, keeping the wings level. Hold the plane between thumb and forefinger just behind the center of gravity. As your technique improves you can throw harder, adjusting the trim as needed. But remember, all planes do not fly at the same speed.

NOTE: Fly Safely. Some of the airplanes in this book have sharp points so never fly them toward another person. If you fly the airplanes outdoors they may go farther than you expect. Be sure they do not go into the street where you will have to retrieve them.

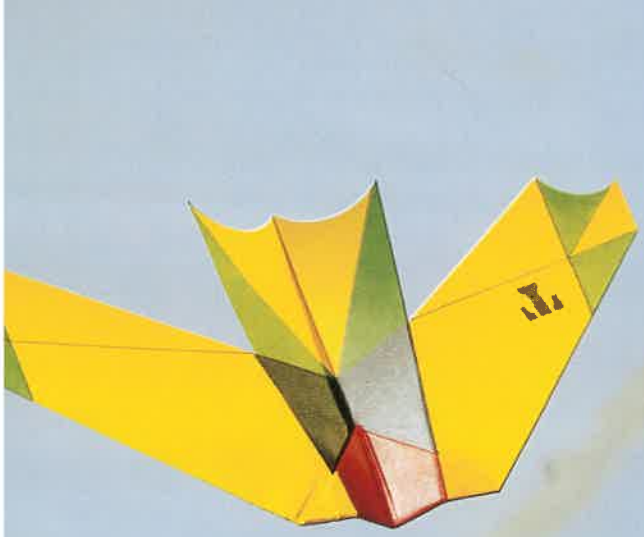
AIRPLANE CONTROL SURFACES

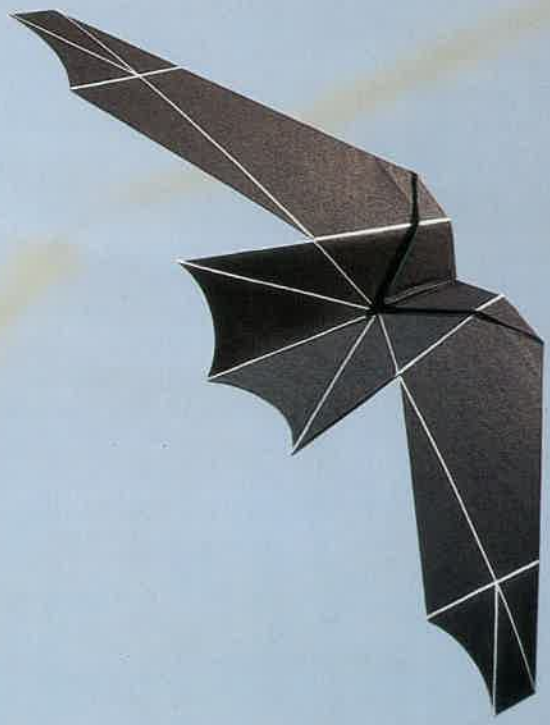


HOW TRIMMING WORKS


Straight airplane: flies straight
Bent airplane: yaws to the left
Bent airpla flies straig but w increa drag
A
B
C
Air flows smoothly on both sides
Air is deflected to the left by bent fuselage
Air is deflected to the left by bent fuselage and to the right by the rudder

Aero Bat





AL INFORMATION

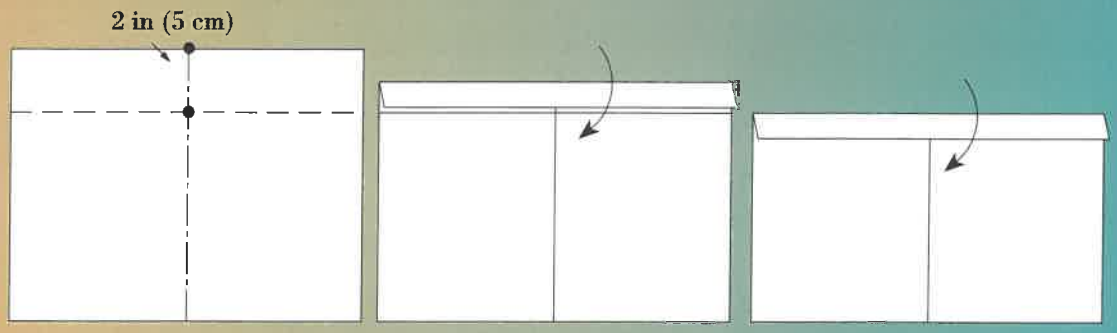
aircraft designers looked to birds and
s about airplane construction. They
ith thin wooden frames cross-braced
nd covered in fabric. For control while
wing tips could be bent up or down as
the pilot. But the airplanes were
ifficult to fly. They often fluttered
me collapsed. Many crashed. Between
d the 1890s Sir George Cayley, Francis
rcy Pilcher, Lawrence Hargrave, Otto
nd others, experimented with various
plane designs. This paper airplane is
early bird-like planes.

Technical Information

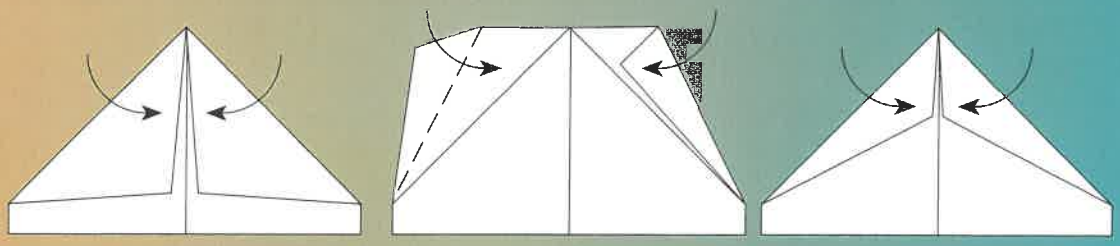
Lift When a wing having a curved upper surface moves forward it slices the air into two layers – one above and one beneath the wing. Both air layers are made up of the same number of molecules, but those that move over the curved top of the wing have farther to go. So they must speed up and spread farther apart which causes them to exert less downward pressure. The molecules of air beneath the wing remain more closely spaced buoying up the airplane. Raising the leading edge of the wing slightly (the angle of attack), increases the difference in pressure above and below the wing, adding more buoyancy.

Gravity This force pulls everything in the world to the ground and opposes lift. Therefore an airplane's center of gravity (the point at which an object balances) must coincide with the lift created by the wings. If it doesn't the airplane is unstable. With the center of gravity too far back the nose will pitch up; too far forward and the nose will pitch down.

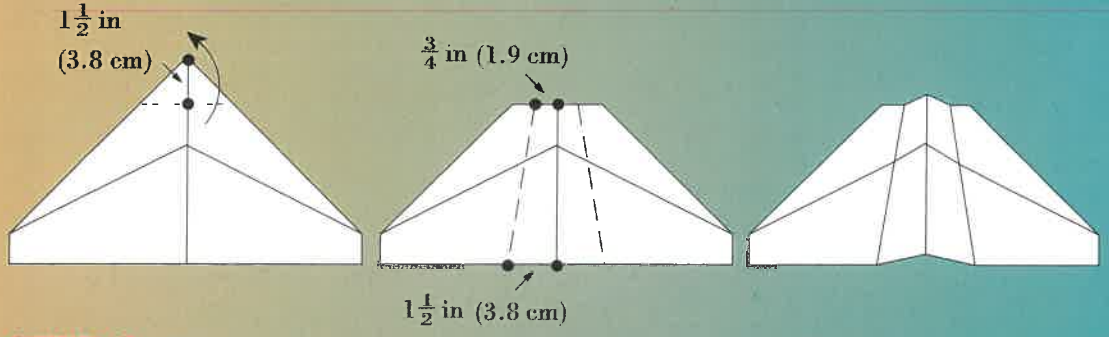
Making the Aero Bat



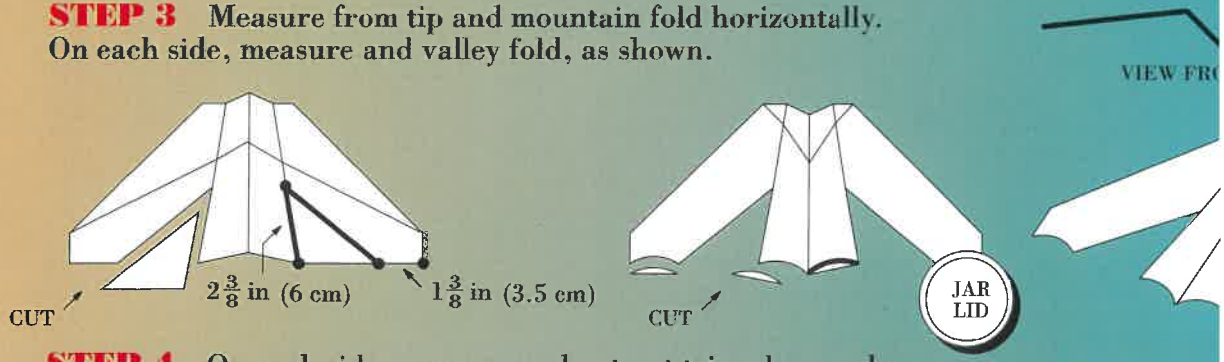
STEP 1 Lay the paper flat in a horizontal direction. Fold paper in half vertically, mountain fold. Unfold. Measure from upper edge and valley fold horizontally. Unfold fold upper edge to meet horizontal crease. Refold original horizontal crease.



STEP 2 Valley fold upper corners to the vertical center crease. Unfold. Valley fold upper corners to the diagonal creases. Then refold original diagonal creases.



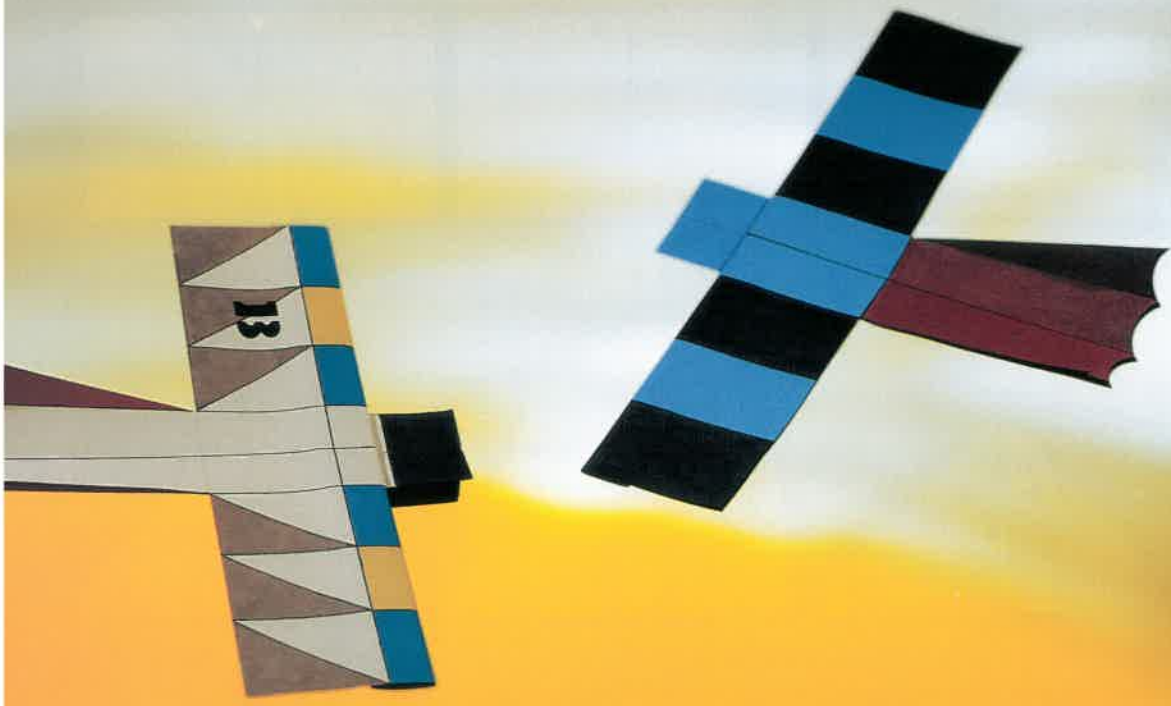
STEP 3 Measure from tip and mountain fold horizontally. On each side, measure and valley fold, as shown.



STEP 4 On each side, measure and cut out triangles, as shown. Flip the airplane over. Then, using a small jar lid, trace scalloped edges and cut out, a Adjust folds so that viewed from the back the plane forms an inverted W.

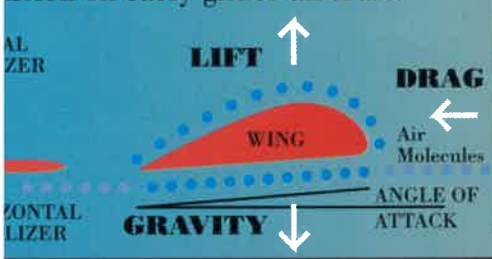
AIRPLANE NUMBER TWO

Sky Bird



INFORMATION

aft had no engines. They were airplane builders used high hills as ts to test their constructions. The realized that in order for airplanes lly, having wings was not enough. needed horizontal and vertical ability. Otto Lilienthal made many er flights in the 1890s. This paper deled on early glider aircraft.



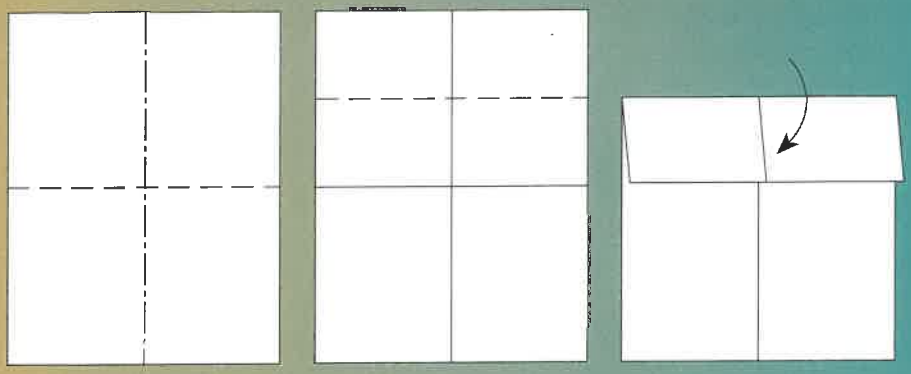
Technical Information

Drag This is the force of resistance that air gives when objects move through it. Because of drag it is hard work to pedal your bike very fast. Drag also acts on an airplane in flight. It is responsible for slowing down a paper airplane.

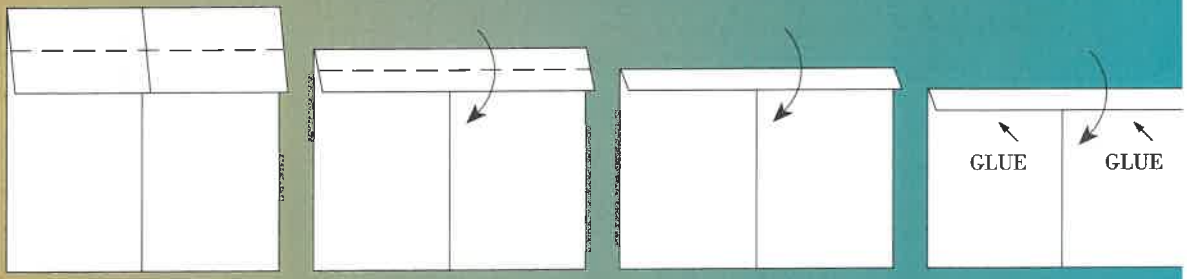
Thrust This is the forward momentum of an airplane. After you launch a paper airplane the force of lift prevents gravity from pulling the plane straight down, but gravity is still at work. In a glider, gravity provides thrust. In flight the nose should point down slightly. In gliding flight, gravity will pull the plane along an invisible mass of air in a gentle downward movement, just as gravity pulls a sled down a hill. If the nose is pointed down too much the plane will dive and crash into the ground.

The four forces – lift, gravity, thrust, and drag – are always present acting together on an airplane in flight.

Making the Sky Bird

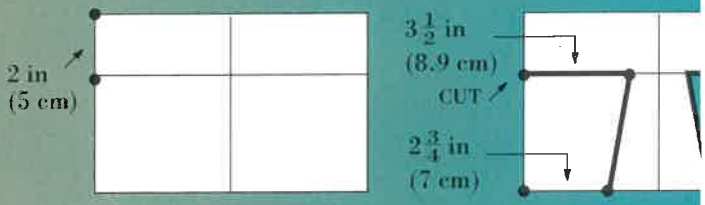


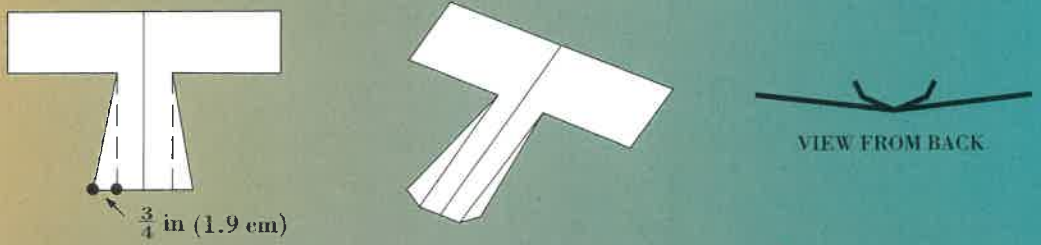
STEP 1 Lay paper flat in a vertical direction. Fold paper in half vertically using a mountain fold. Unfold. Valley fold the paper in half horizontally. Unfold. Then valley fold the top to meet the horizontal crease.



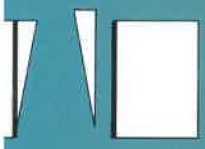
STEP 2 Valley fold the top again to meet the horizontal crease. Then valley fold top again, to meet the horizontal crease. Finally, applying glue to entire length, refold the original horizontal crease.

STEP 3 Flip over. Measure from top and draw line, as shown. On each side, measure and cut out along heavy lines to make wings and tail, as shown.

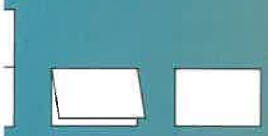




STEP 4 On each side of tail, measure and valley fold. Adjust dihedral (upward slanting of wings and tail), as shown.

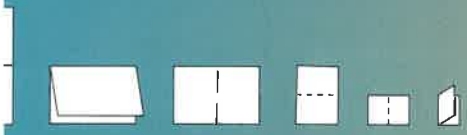


P 5 Cut the two pieces left over from step 3 into rectangles, as shown.



P 6 To make the fuselage), valley fold piece A in half ontally. Glue halves together.

STEP 7 Valley fold this piece in half vertically. Then fold each vertical edge back to meet center crease. Glue center section. This is the fuselage.

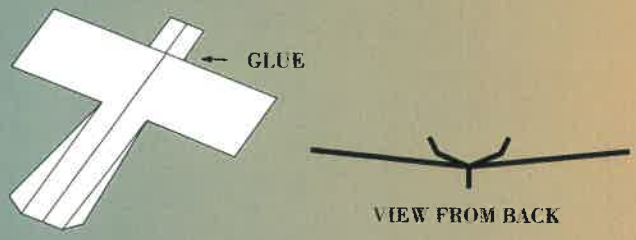


P 8 To make nose ballast, valley fold B in half horizontally. Glue halves ıer. Valley fold in half vetically. Glue s together. Then valley fold in half ontally. Glue halves together. Finally, fold in half vertically.

STEP 9 Glue this piece to the bottom of the center section of the fuselage, aligning at one of the ends. This end becomes the front.

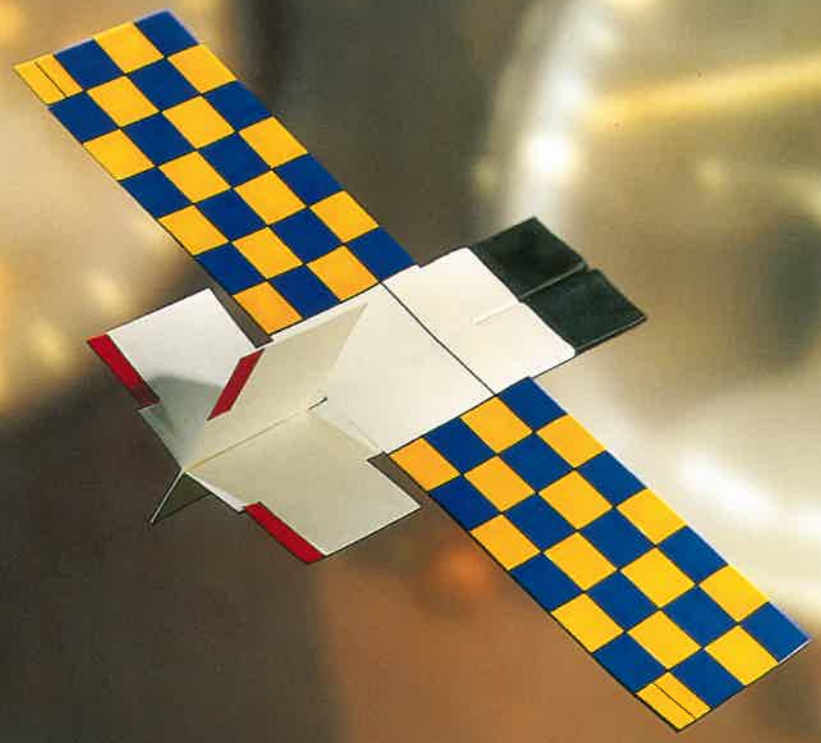
1 in (2.5 cm)

P 10 Measure from front of ge and mark the point, as shown.



STEP 11 Glue wings and tail to the fuselage with the leading edge (front of the wings)at the measured point. Make sure pieces are centered. Adjust dihedral (upward slanting of wings and tail) again.

Plain Plane



HISTORICAL INFORMATION

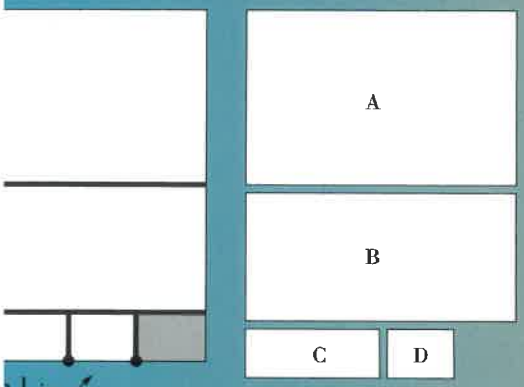
Achieving stability in flight was a major concern for early airplane designers, and remains so today. In the early days many different airplane shapes were tried. The most practical arrangement of parts had wings near the middle attached to a fuselage (body) with a tail at the back that had both horizontal and vertical surfaces. The fuselage also had room for the pilot. This arrangement has become the conventional and most often used aircraft design. Movable surfaces were added to the trailing (back) edges of wings and stabilizers: ailerons on the wing tips controlled roll (rotation along the length of an airplane), elevators on the horizontal tail controled pitch (nose up or down), and a rudder on the vertical tail controled yaw (nose left or right). This paper airplane is modeled on the conventional airplane.

Technical Information

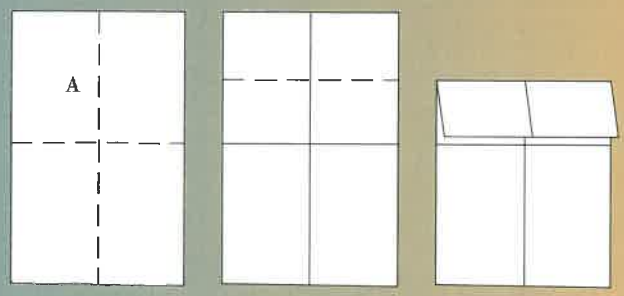
If an airplane is to be stable in flight, i
get the center of gravity in the correct
in this book are designed with the cor
gravity location, but if more ballast is
the nose by using a small piece of pap
plasticine, some clear tape, or a small
construction results use the 20 or 24
paper recommended, measure accura
crisp folds. Use glue sparingly, but use
the parts together.

While an airplane is in flight the four f
thrust, and drag) must be in balance.
is in trim for straight and level flight.
need frequent small adjustments to th
in order to fly well. You may need to m
adjustments for indoor flight than for
lively air. Always make small correctio
small adjustment has a big effect.

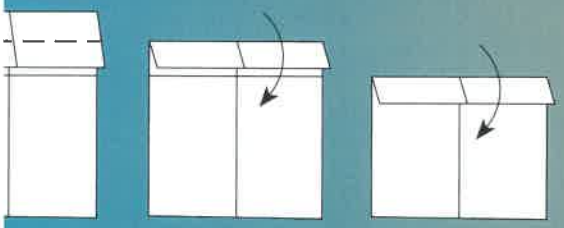
aking the Plain Plane



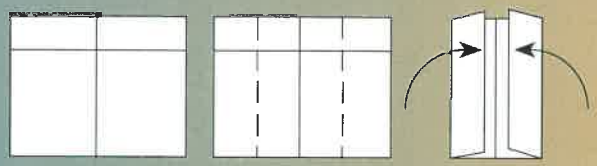
P 1 Measure and cut the various pieces a sheet of bond paper, as shown.



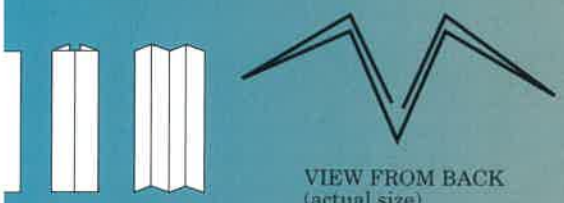
STEP 2 Lay piece A flat in a vertical direction. To make the fuselage, fold in half vertically using a valley fold. Unfold. Valley fold in half horizontally. Unfold. Then valley fold the top to meet the horizontal crease.



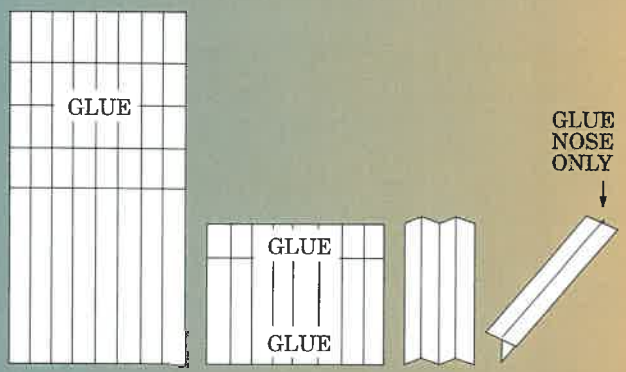
P 3 Valley fold the top again to meet the ntal crease. Refold the original crease.



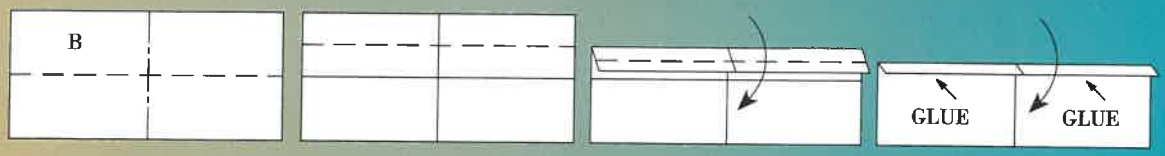
STEP 4 Valley fold each side so that outer edges meet center crease, as shown.



P 5 Fold each side again using a tain fold, so that outer edges meet r crease at back. Then adjust folds so per looks like an upside-down W, own.



STEP 6 Unfold fuselage (piece A) completely. Refold applying glue to contacting surfaces, as shown. Make sure fuselage is straight.



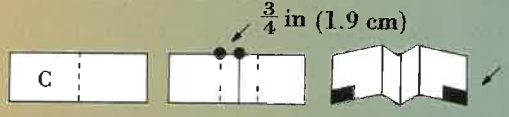
STEP 7 Use piece B to make the wings. Lay paper flat horizontally. Fold in half vertically, using a mountain fold. Unfold. Fold in half horizontally, using a valley fold. Unfold. Then valley fold so that top edge meets center crease. Fold again so that top ed meets center crease. Applying glue to entire length, refold original horizontal center crease. The folded over part is the bottom of the leading edge (front) of the wings.

AILERONS
$\frac{3}{4}$ in x $\frac{1}{4}$ in
(1.9 cm x .6 cm)

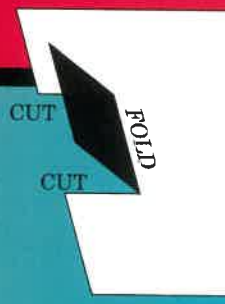
NOTE In the instructions, control surfaces (ele ailerons, rudder) are shown in black. The cuts a $\frac{1}{4}$ in (.6 cm) or $\frac{3}{8}$ in (1 cm) deep on the ends. Width different airplanes. Their dimensions are written

$\frac{3}{4}$ in x $\frac{1}{4}$ in (1.9 cm x .6 cm) or $1\frac{1}{4}$ in x $\frac{1}{4}$ in (3.1 cm x .6 cm)

STEP 8 Make ailerons on trailing (back) edges.



ELEVATORS
$\frac{3}{4}$ in x $\frac{1}{4}$ in
(1.9 cm x .6 cm)

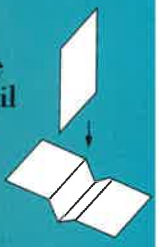


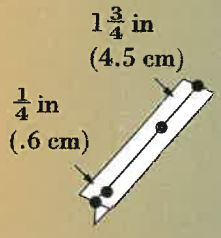
STEP 9 Use piece C to make the horizontal tail. Valley fold in half vertically. Unfold. On each side, measure from center crease, as shown, and mountain fold along dotted lines. Make elevators on trailing edges.

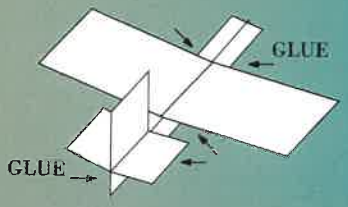
RUDDER
$\frac{3}{4}$ in x $\frac{1}{4}$ in
(1.9 cm x .6 cm)

STEP 10 Use piece D to make the vertical tail. Make rudder on trailing (back) edge, as shown.

STEP 11 Apply glue to inside of horizontal tail and insert vertical tail, aligning trailing (back) edges.



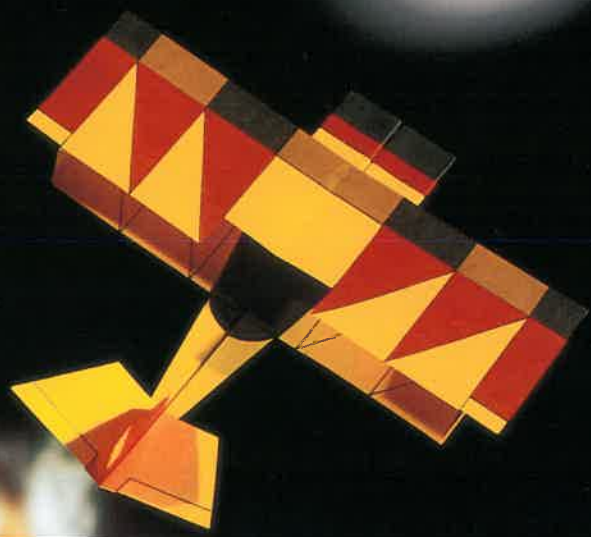




STEP 12 Measure and make marks for positioning tail and wings.

STEP 13 Applying glue, slide tail into fuselage. Th apply glue to wings and attach to fuselage. Adjust dihedral (upward slanting of wings and tail).

Biplane



AL INFORMATION

improve lift without making large wings
ng two sets of them, one above the
nes). The box-like construction of these
ade it easy to cross-brace the
wooden frames with wire for strength.
ville and Wilbur Wright put an engine
ne and became the first to attain
owered flight. Biplanes were used for
air battles of World War I, which began
ghter biplanes were highly
ble although difficult to handle. Some
re the Spad 7, Sopwith Camel, and
Biplanes are now used where small,
d maneuverable airplanes are
Crop spraying is a good example. This
ane is modeled on early biplanes.

Technical Information

Biplanes have stubby noses and short wings and tails, making them sensitive to pitch and roll because the distances from the center of gravity to the control surfaces are small. The planes require careful trimming.

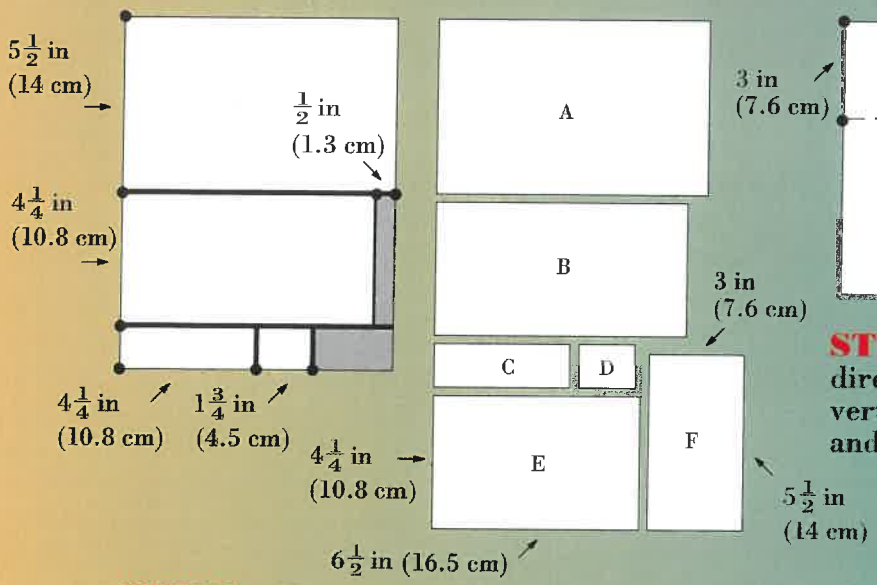
If the airplane zooms nose down to the ground, bend the elevators up slightly to raise the nose in flight.

This may cause the nose of the plane to pitch up sharply. As a result the air no longer flows smoothly over the wing surfaces but separates into eddies and the wings stall. To solve this problem bend the elevators up less.

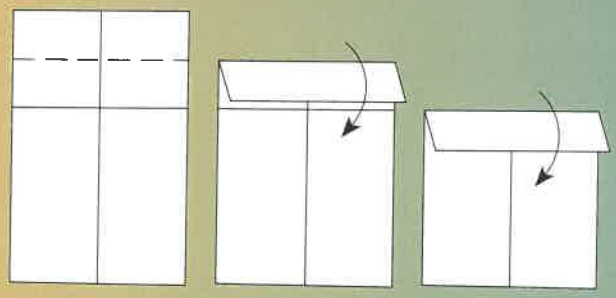
If the elevators are not bent at all and the nose still rises, don't bend the elevators down to correct the problem (a plane should never fly this way). Rather add a bit of extra ballast to the nose.

If the plane veers to left or right, bend the aileron up slightly on the wing that rises and down slightly on the wing that falls. Also bend the rudder on the vertical tail slightly, opposite to the direction of the turn.

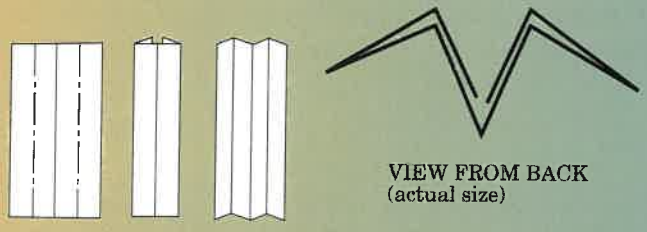
Making the Biplane



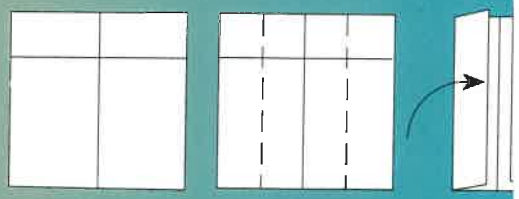
STEP 1 Measure and cut the various pieces from a sheet of bond paper, as shown. Two additional pieces E and F are needed, as shown.



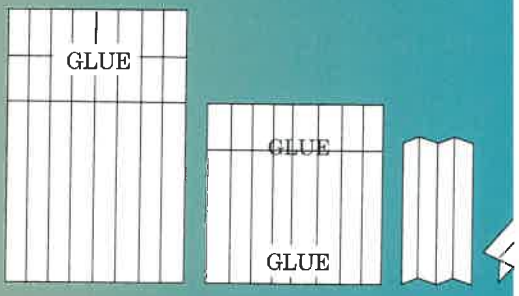
STEP 3 Valley fold the top to meet the horizontal crease. Then refold the original horizontal crease.



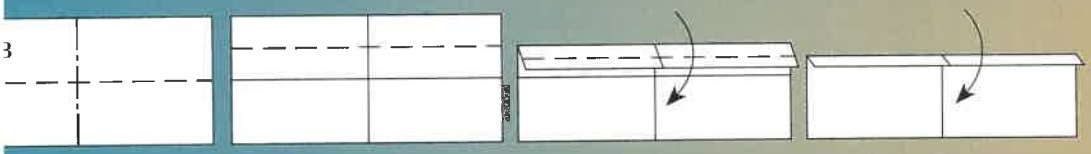
STEP 5 Fold each side again using a mountain fold, so that outer edges meet center crease at back. Then adjust folds so that paper looks like an upside-down W, as shown.



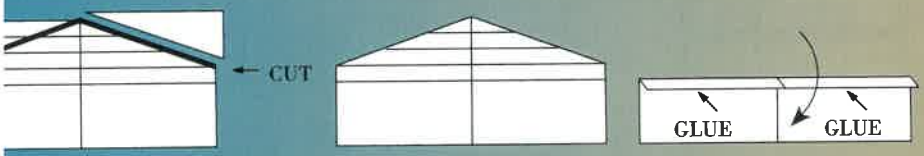
STEP 4 Valley fold each side so th outer edges meet center crease, as sh



STEP 6 Unfold fuselage completel Refold applying glue to all contacting surfaces, as shown. Make sure fuselag is straight. Do not glue nose yet.

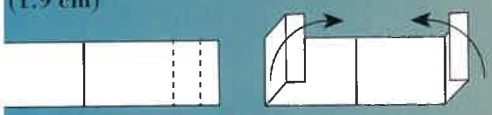


EP 7 Lay piece B in a horizontal position to make the lower wings. Fold in vertically, using a mountain fold. Unfold. Fold in half horizontally, using a y fold. Unfold. Then valley fold so that top edge meets center crease. Fold again at top edge meets center crease. Refold original horizontal center crease.

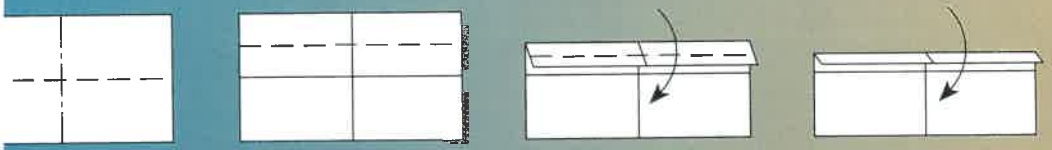


EP 8 Unfold completely. On each side, measure and cut diagonally, as shown. ld. Apply glue before refolding original horizontal center crease only. The folded part is the bottom of the leading edge (front) of the wings.

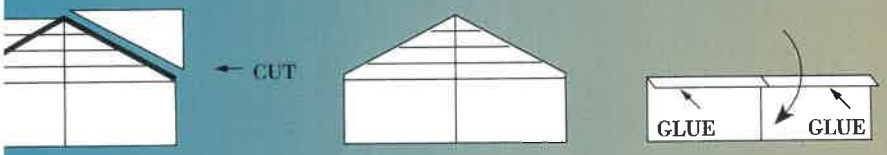
$\frac{3}{4}$ in
(1.9 cm)



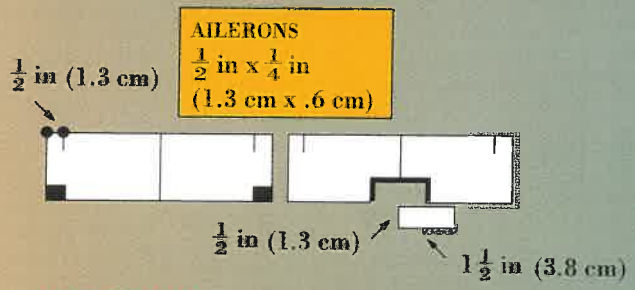
EP 9 On each side, measure and valley fold, as shown.



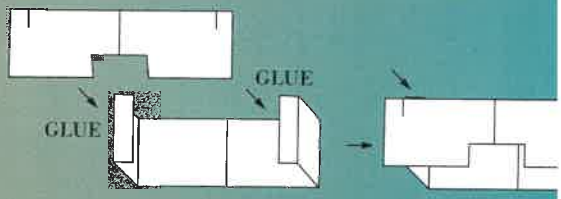
EP 10 Lay piece E horizontally to make the upper wings. Fold in half ically, using a mountain fold. Unfold. Fold in half horizontally, using a valley . Unfold. Then valley fold so that top edge meets center crease. Fold again so top edge meets center crease. Refold original horizontal center crease.



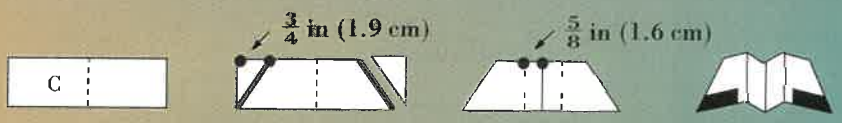
EP 11 Unfold completely. On each side, measure and cut diagonally, as wn. Refold. Apply glue before refolding original horizontal center crease only. folded over part is the bottom of the leading edge (front) of the wings.



STEP 12 On each side of upper wings, measure from each wing tip and mark attachment points for lower wings, as shown. Cut out center piece on trailing edge, as shown. Make ailerons in locations indicated.

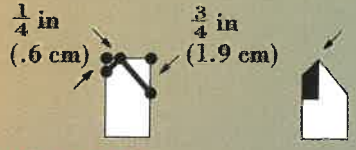


STEP 13 Applying glue, fasten
and lower wings together, as shown.
sure both leading edges face the sam
direction.



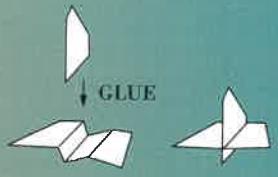
ELEVATORS
$1\frac{1}{4}$ in x $\frac{1}{4}$ in
(3.1 cm x .6 cm)

STEP 14 Use piece C to make the horizontal tail. Valley fold in half vertically. Unfold. On each side, measure from outer edges, as shown, and cut along heavy lines. Then, on each side, measure from center crease and mountain fold, as shown. Make elevators.

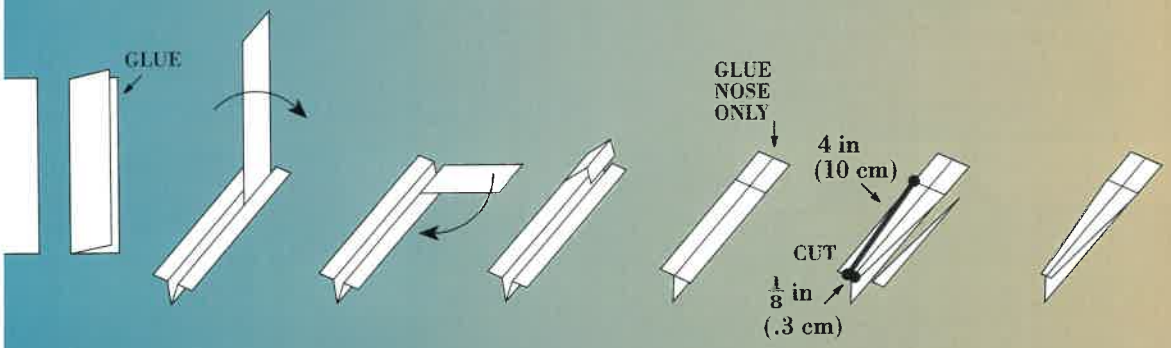


RUDDER
$\frac{3}{4}$ in x $\frac{1}{4}$ in
(1.9 cm x .6 cm)

STEP 15 Measure and cut leading edge along heavy lines, as shown. On trailing edge, make rudder.

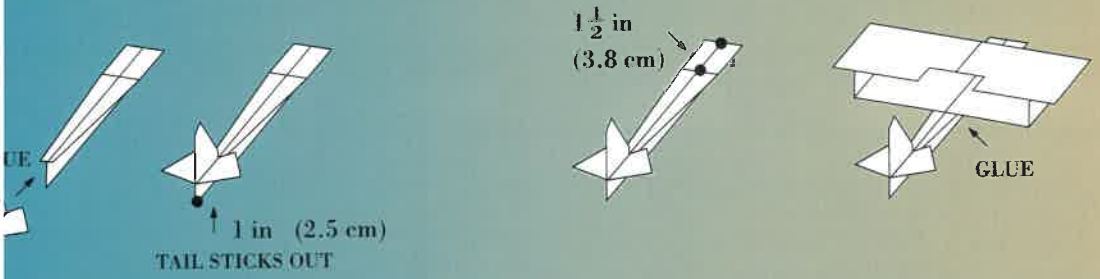


STEP 16 Apply glue to inside o
horizontal tail and insert vertical t
aligning trailing (back) edges.



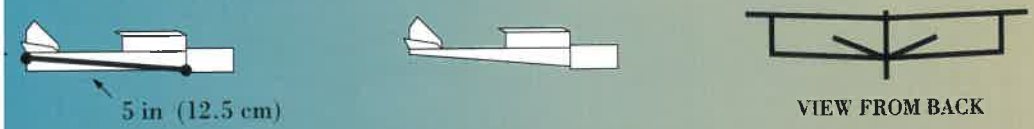
EP 17 Use piece F to make the nose cowl (ballast). ey fold piece in half vertically. Glue halves together. lying glue to one side, insert F into nose and wrap rely around fuselage, as shown. Then glue fuselage ther at nose only.

STEP 18 On each side, measure and cut fuselage back along heavy lines, as shown.



EP 19 Applying glue, slide the into the back of the fuselelage.

STEP 20 Measure from front of fuselage and mark front of wing position. Glue wings in place, as shown.



EP 21 Measure and cut back of fuselage, hown. Adjust dihedral (upward slanting of gs and tail) to finish airplane.

Aero Stunt

HISTORICAL INFORMATION

Ever since the earliest days of flight, flying events attracted great crowds of spectators. After World War I, many pilots performed aerial maneuvers learned in combat as stunts for entertainment. Sometimes people walked on the wings, or even jumped from one plane to another, while the airplanes were in flight. Such events (called barnstorming) thrilled spectators, and even today, air shows where aerobatics are performed, draw huge crowds. As planes improved, air racing became popular. Speeds exceeded 200 mph. This paper airplane is designed specifically to do stunts. It will not fly straight and level.

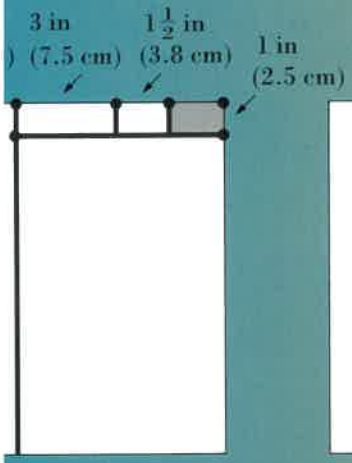
Technical Information

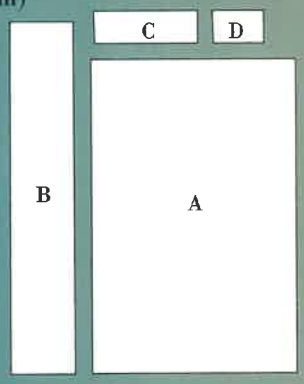
Loops When an airplane flies a loop it m its speed throughout the entire maneuv round loop depends on centrifugal force pushes the plane outwards, much like sw a string. Only there is no string to hold plane's wings create a centripedal force from flying off and distorting the loop.

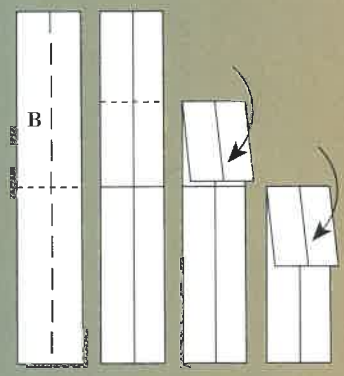
Rolls When the ailerons are used, one l and the other one bends down. This cau to bank in the direction of the upward b powered airplane can roll completely, o flying along in corkscrew fashion.

Hammerheads In this maneuver the air straight up, but before it stalls the plane that it points straight down, swooping sm the dive.

laking the Aero Stunt

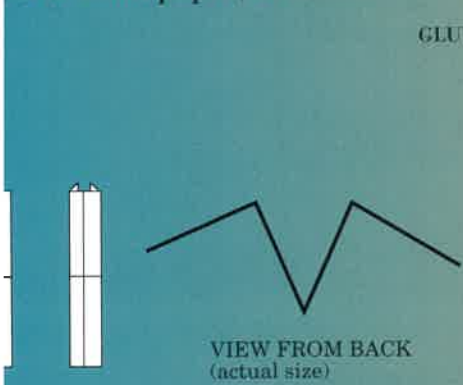


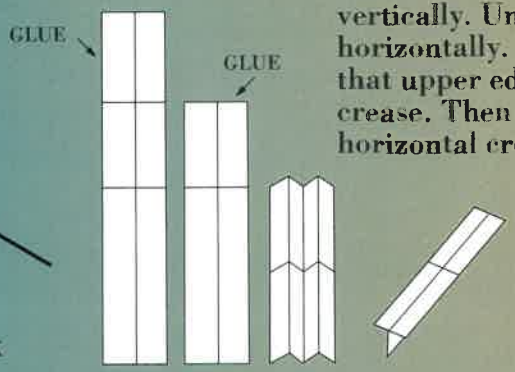




EP 1 Measure and cut four pieces from eet of bond paper, as shown.

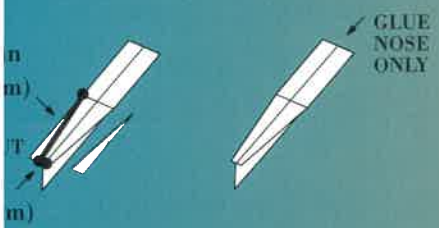
STEP 2 Lay piece B vertically to make the fuselage. Valley fold in half vertically. Unfold. Valley fold in half horizontally. Unfold. Valley fold so that upper edge meets the horizontal crease. Then refold the original horizontal crease.



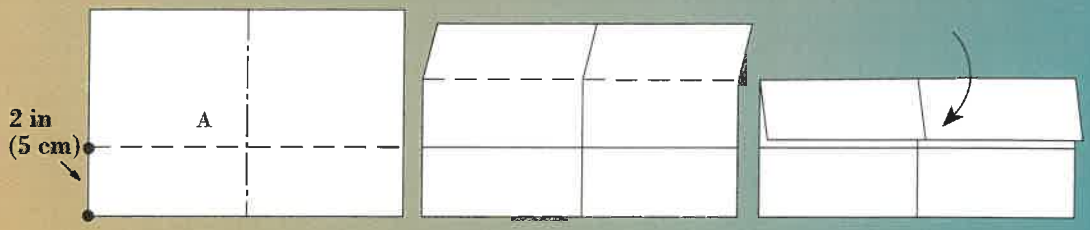


EP 3 Fold each side using a ntain fold so that outer edges t center crease at back. Then st folds so that paper looks like pside-down W, as shown.

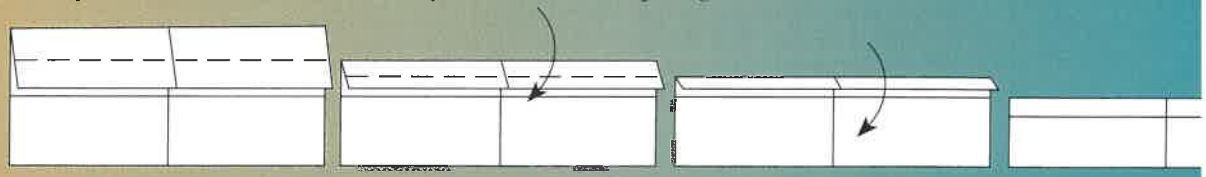
STEP 4 Unfold fuselage completely. Refold applying glue to all contacting surfaces, as shown. Make sure fuselage is straight.



EP 5 On each side, sure and cut fuselage back g heavy lines, as shown. n glue nose only.



STEP 6 Lay piece A horizontally to make the wings. Fold in half vertically, using a mountain fold. Unfold. Measure from the bottom and fold horizontally, using a valley fold. Unfold. Then valley fold so that top edge meets horizontal crease.

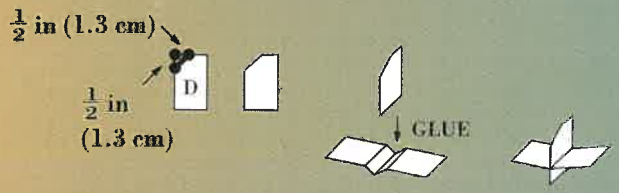


STEP 7 Valley fold so that top edge meets horizontal crease. Again valley fold so that top edge meets horizontal crease. Then refold original horizontal crease.

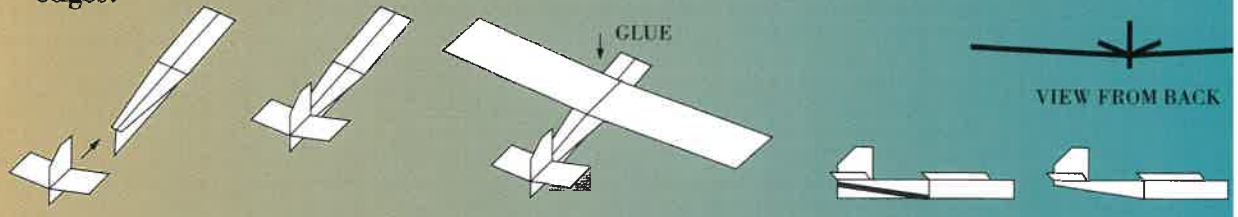
NOTE: surfaces are diff the othe

STEP 8 Unfold the last fold only and apply glue to entire length. Refold. Make ailerons by folding diagonally, as shown.

STEP 9 Use piece C to mak horizontal tail. Valley fold in h vertically. Unfold. On each sid measure from center crease an mountain fold, as shown. Mak elevators by folding diagonally shown.



STEP 10 Use piece D for the vertical tail. Measure and cut diagonally along heavy li shown. Then apply glue to inside of horizontal tail and insert vertical tail, aligning trailin edges.



STEP 11 Applying glue, slide the tail into the back of fuselage, aligning trailing edges.

STEP 12 Applying glue, attach wings so that trailing edges align with seam on the fuselage.

STEP 13 Cut fuselage diagonally from the seam to the back, as shown by heavy line. Adjust dihedral (upward slanting of wings and tail), as shown.

Gee Bee Racer

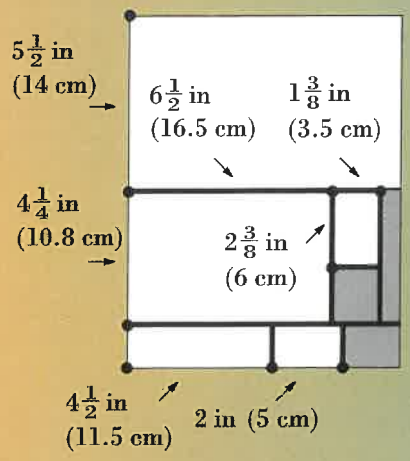
AL INFORMATION

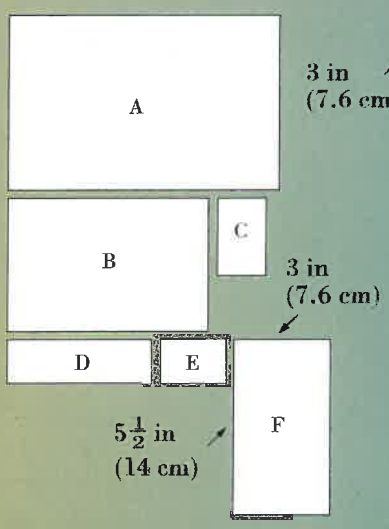
ery beginning of powered flight, it
parent that airplanes and speed
gether. Air races were established so
rs could compete with one another.
ılar races were the Thompson Race, the
e, and the Shell Speed Dash. In 1932
lle brothers built the Gee Bee model R
mpete in all three races. Two R models
That year they won the Thompson and
peed Dash record of almost 300 mph. It
skill to fly at high speed near the ground
mental airplane such as a racer. Both
ıtually crashed, and two pilots lost their
y another Gee Bee, just like the
as been built. It is a popular attraction
shows.

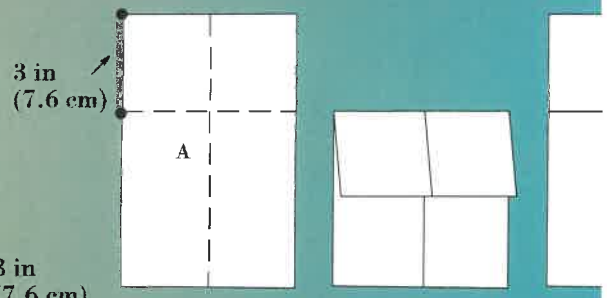
Technical Information

The Gee Bee model R is mostly a flying engine. Its big radial engine produces over 500 horsepower. Drag is the enemy of the racer. To go fast, even with a powerful engine, drag must be kept at a minimum. When this plane was being designed, different shapes were tested in a wind tunnel to find a shape that had the least amount of drag. A fat and stubby "teardrop" shape was found to be ideal. But such a stubby shape makes for a tempermental plane to fly. All airplanes that are stubby with short wings and tails are sensitive to pitch and roll because the distances from the center of gravity to the control surfaces are short. This paper model, however, is a remarkably good flyer.

Making the Gee Bee

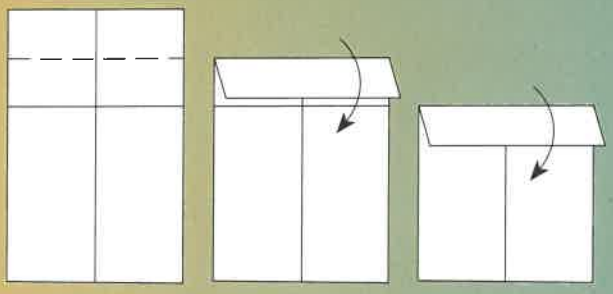




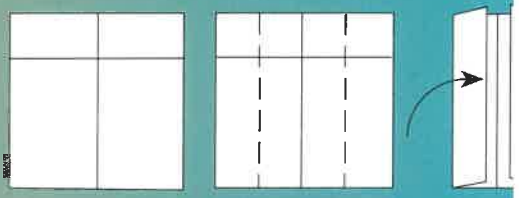


STEP 2 Lay piece A flat in a vert direction. Fold in half vertically usi fold, to make the fuselage. Unfold. M valley fold horizontally, as shown. U

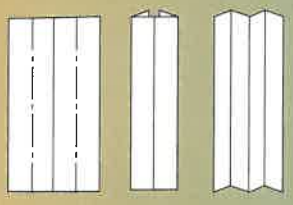
STEP 1 Measure and cut the various pieces from a sheet of bond paper, as shown. One additional piece F is needed, as shown.



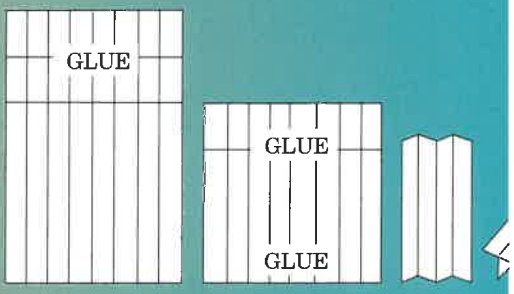
STEP 3 Valley fold the top to meet the horizontal crease. Then refold the original horizontal crease.



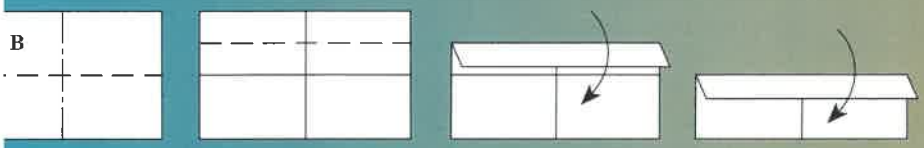
STEP 4 Valley fold each side so th outer edges meet center crease, as sho



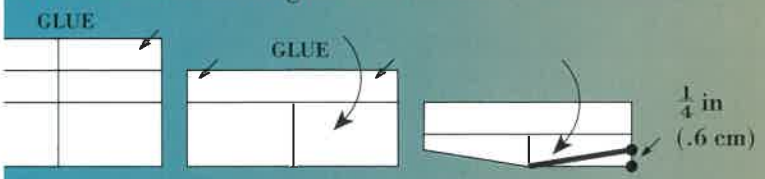
STEP 5 Fold each side again using a mountain fold, so that outer edges meet center crease at back. Then adjust folds so that paper looks like an upside-down W, as shown.



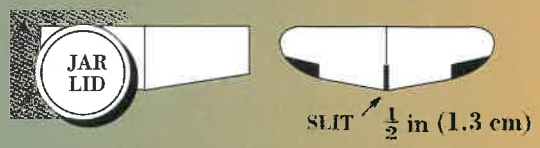
STEP 6 Unfold fuselage complete Refold applying glue to all contacting surfaces, as shown. Make sure fusela is straight. Do not glue nose yet.



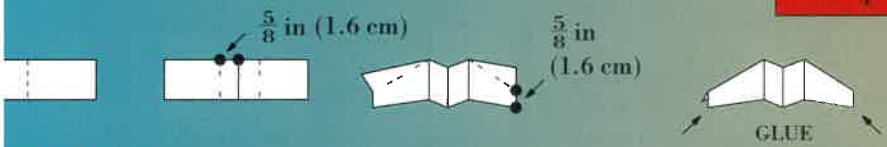
EP 7 Lay piece B in a horizontal direction to make the wings. Fold alf vertically, using a mountain fold. Unfold. Fold in half horizontally g a valley fold. Unfold. Then valley fold again so that top edge meets er crease. Refold original horizontal center crease.



AILERONS
$\frac{3}{4}$ in x $\frac{1}{4}$ in
(1.9 cm x .6 cm)



EP 8 Unfold completely. Refold, applying to no more than 1 in (2.5 cm) from outer tips, hown. The folded over part is the bottom of the ling edge (front) of the wings. Measure and cut ling edges, as shown.



STEP 9 Trace around a small jar lid and cut out to round the wingtips. Make slit and ailerons, as shown.

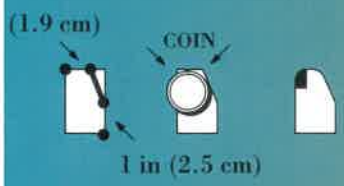
FOR MAKING ROUNDED CORNERS USE
JAR LID 2 in (5 cm)
COIN $\frac{3}{4}$ in (1.9 cm)

NOTE: There are several planes that require rounded corners. These objects work well.

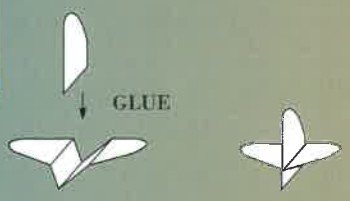
EP 10 Use piece D to make the horizontal tail. Valley fold in half vertically. old. On each side, measure from center crease and mountain fold, as shown. On side, measure and mountain fold leading (front) edges, as shown. Glue.

ELEVATORS
$1\frac{1}{4}$ in x $\frac{1}{4}$ in
(3.1 cm x .6 cm)

EP 11 Trace around a coin and cut out to make rounded outer corners. Make ators in locations shown.

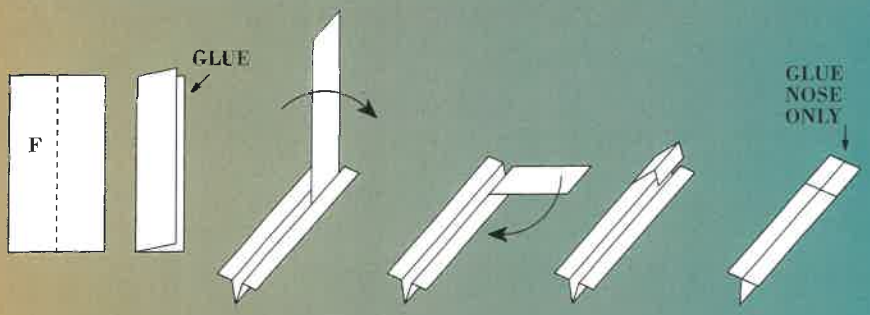


RUDDER
$\frac{1}{2}$ in x $\frac{1}{4}$ in
(1.3 cm x .6 cm)

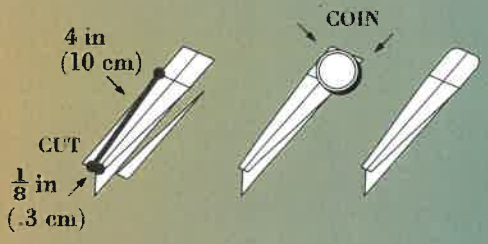


EP 12 Use piece E to make the vertical tail. sure and cut leading (front) edge as shown eavy line. Trace around a coin and cut out ound corners. On trailing edge, make rudder.

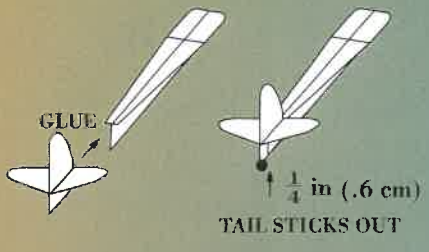
STEP 13 Apply glue to inside of horizontal tail and insert vertical tail, aligning trailing (back) edges.



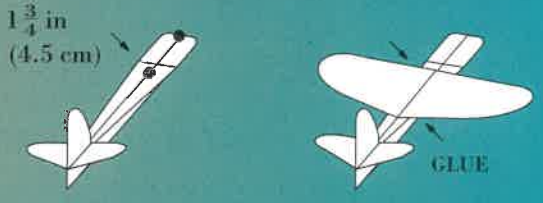
STEP 14 Use piece F to make the nose cowl (ballast). Valley fold piece in half vertically. Glue halves together. Applying glue to one side, insert F into nose and wrap entirely around fuselage, as shown. Then glue fuselage together at nose only.



STEP 15 On each side, measure and cut fuselage back along heavy lines, as shown. Trace around a coin and cut out to round the nose.

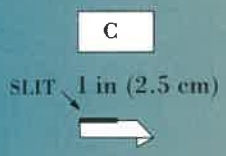


STEP 16 Applying glue, slide the tail into the back of the fuselage.

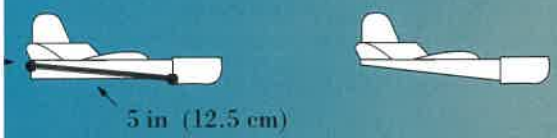


STEP 17 Measure from front of fuselage and mark front of wing position. Glue wings in place, as shown.

NOPY (type 1)
in x 2 $\frac{3}{8}$ in (3.5 cm x 6 cm)
point 1 in (2.5 cm)



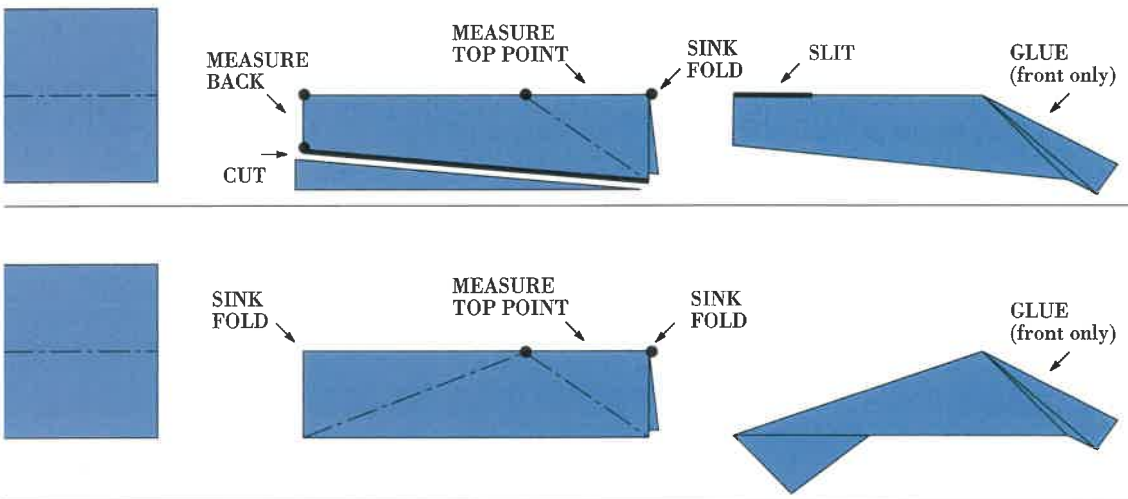
EP 18 Make the canopy, using
e C (see below). Make a slit at the
ter back, as shown.



STEP 19 Apply glue to the inside back and front tab of the canopy. Insert tab into the fuselage, sliding the vertical tail into the slit.

EP 20 Measure and cut back of fuselage,
hown. Adjust dihedral (upward slanting of
gs and tail) to finish airplane.

s the first airplane design in this book to have a canopy. The canopy adds
as ballast. There are two main types, as shown below. Dimensions are given
lane design.



t paper to dimensions
rticular airplane. Lay
zontal direction. Fold
', using a mountain

(b) With the paper folded in half as in step (a), measure top point and draw lines. For type 1, sink-fold (see p 6) the front corner and cut on heavy line. For type 2, sink fold front and back corners.

(c) Press flat to finish the canopy. Only the front end should be glued.

NOTE: When viewed from the top, in attaching the canopy, let sides flare out. This is important because it gives shape to the plane.

AIRPLANE NUMBER SEVEN

P47 Thunderbolt

HISTORICAL INFORMATION

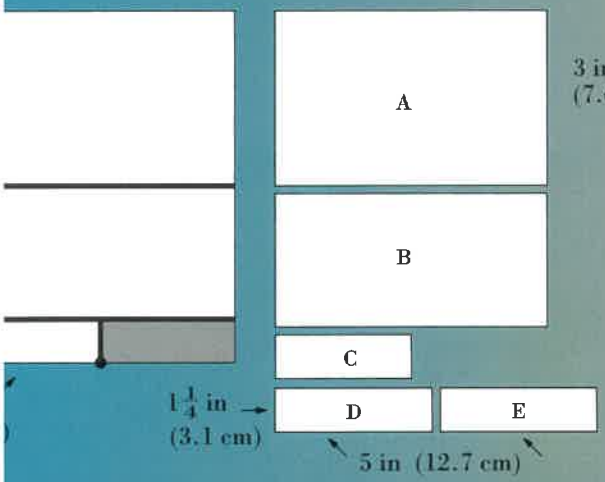
With the outbreak of another world war in 1939, there was again a demand for maneuverable fighter planes. Streamlined airframes capable of great speed were designed. More powerful engines were made, pushing speeds past 400 mph. Some popular examples of fighters are the Republic P47, North American P51, Supermarine Spitfire, Messerschmitt ME109, and the Mitsubishi "Zero". After the war ended in 1945 some of these warplanes became sport planes, and these inspired the building of aircraft using aerodynamic and technical information gained from fighter design. This paper airplane is modeled on the fighters of World War II and present-day sport planes.

Technical Information

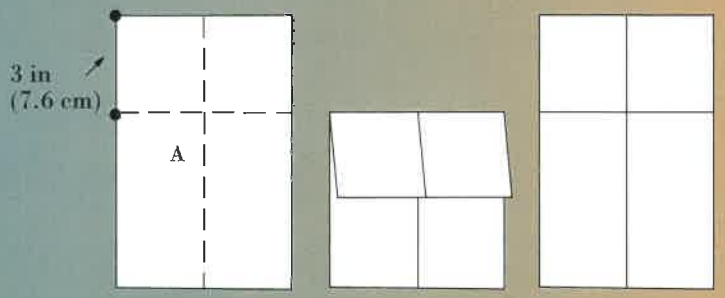
Speed and Drag: From the very beginnin
flight it was realized that speed and flight
together. The unobstructed freedom that
combined with speed, made it easy and fa
place to place. The biplanes of World Wa
engines about as powerful as those found
could exceed 100 mph. The fighters of W
with much more powerful engines, could
mph. With such an increase in speed, dra
increased and airplane builders had to fin
reduce it as much as possible. One way wa
corners and removing things that stuck o
airflow (streamlining) and hiding them un
smooth skin.

In slow flight (as in landing) airplanes that
need a method of increasing the lift of the
wings. They have secondary control surfa
flaps, that bend down on the trailing edge
near the fuselage. Flaps are used not only
but also for takeoff or whenever extra lift

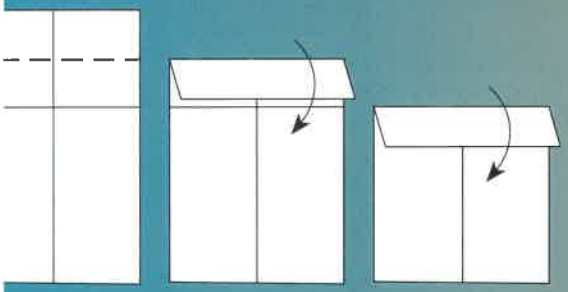
Making the P47



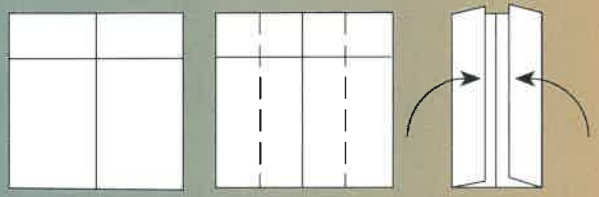
STEP 1 Measure and cut the various pieces from a sheet of bond paper, as shown. Two additional pieces D and E are needed, as shown.



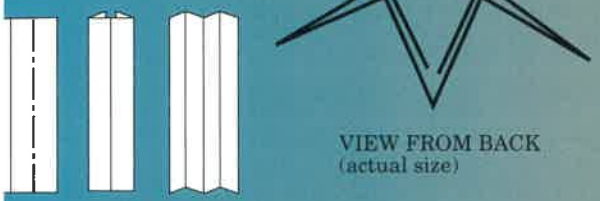
STEP 2 Lay piece A flat in a vertical direction to make the fuselage. Fold in half vertically using a valley fold. Unfold. Measure and valley fold horizontally, as shown. Unfold.



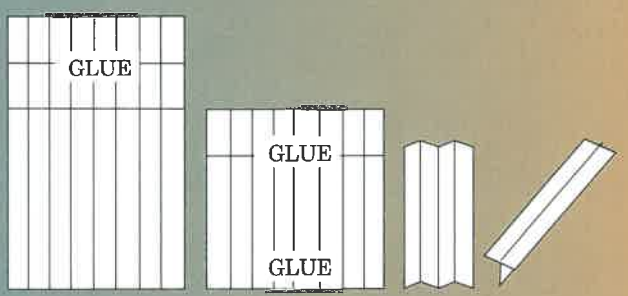
STEP 3 Valley fold the top to meet the horizontal crease. Then refold the original horizontal crease.



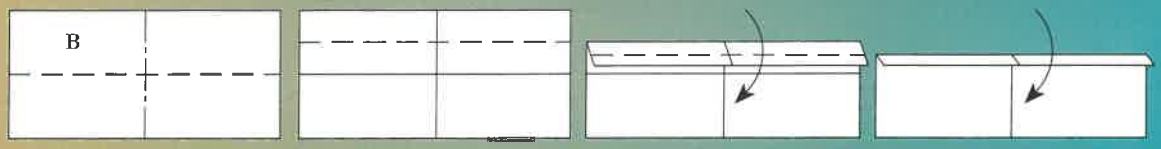
STEP 4 Valley fold each side so that outer edges meet center crease, as shown.



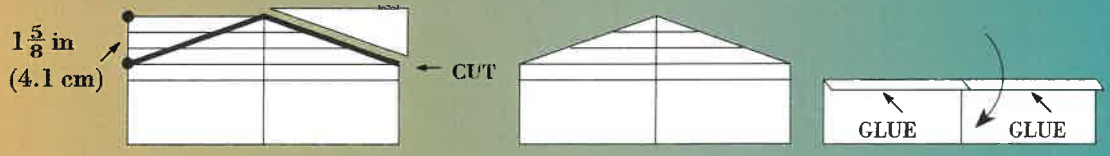
STEP 5 Fold each side again using a mountain fold, so that outer edges meet center crease at back. Then adjust folds so that paper looks like an upside-down W, as shown.



STEP 6 Unfold fuselage completely. Refold applying glue to all contacting surfaces, as shown. Make sure fuselage is straight. Do not glue nose yet.

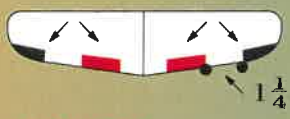


STEP 7 Lay piece B horizontally to make the wings. Fold in half vertically, using a mountain fold. Unfold. Fold in half horizontally, using a valley fold. Unfold. Then valley fold so that top edge meets center crease. Fold again so that top edge meets center crease. Refold original horizontal center crease.



STEP 8 Unfold completely. On each side, measure and cut diagonally, as shown. Refold. Apply glue before refolding original horizontal center crease only. The folded over part is the bottom of the leading edge (front) of the wings.

STEP 9 Measure and cut trailing edge (back) of wings, as shown. Trace around a coin to make rounded corners at the leading edges and a small jar lid for the trailing edge, and cut out (see p 26). Make ailerons, as shown.

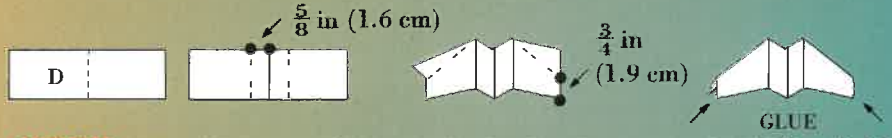


AILERONS
1 in x 1/4 in
(2.5 cm x .6 cm)

FLAPS
1 1/4 in x 1/4 in
(3.1 cm x .6 cm)

NOTE: In the instructions, secondary control surfaces (flaps) are shown in red.

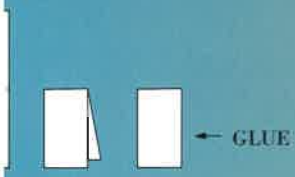
STEP 10 On trailing edges, make ailerons. Then make secondary control surfaces (flaps), in locations shown.



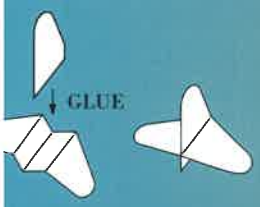
STEP 11 Use piece D to make the horizontal tail. Valley fold in half vertically. Unfold. On each side, measure from center crease, as shown, and mountain fold. On each side, measure and mountain fold leading (front) edges, as shown. Glue.

ELEVATORS
1 1/2 in x 1/4 in
(3.8 cm x .6 cm)

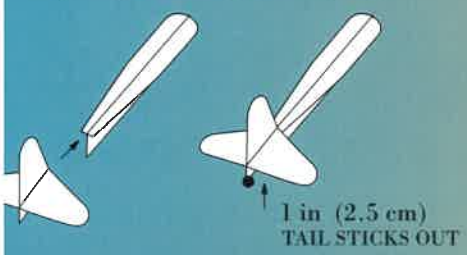
STEP 12 Trace around a coin and cut out to make all the corners rounded (see p 26). Make elevators, as shown.



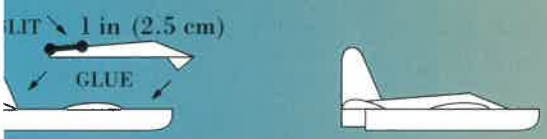
TEP 13 Use piece E to make the tical tail. Mountain fold in half izontally, glue halves together.

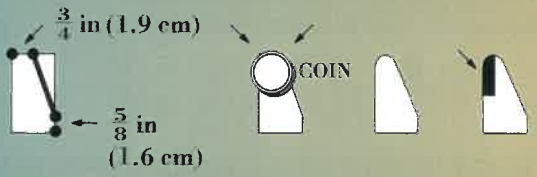


TEP 15 Apply glue to inside of izontal tail and insert vertical , aligning trailing (back) edges.



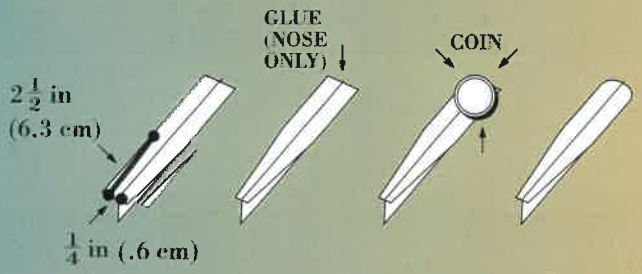
TEP 17 Applying glue, slide e tail into back of fuselage.





RUDDER
3/4 in x 1/4 in
(1.9 cm x .6 cm)

STEP 14 Measure and cut leading edge along heavy line, as shown. Trace around a coin and cut out to round corners (see p 26). On trailing (back) edge, make rudder.

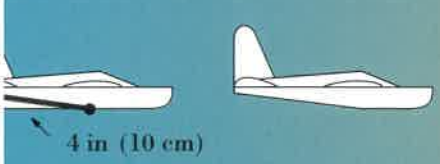


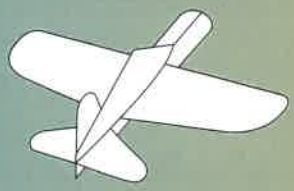
STEP 16 On each side, measure and cut fuselage back, as shown. Then glue nose only. To round corners, trace around a coin and cut out all corners of the nose (see p 26).

STEP 18 Measure from front of fuselage and glue wings in place, as shown.

CANOPY (type 1)
1 1/4 in x 4 1/4 in (3.1 cm x 10.8 cm)
Top point 1 in (2.5 cm)
Back 3/8 in (1 cm)

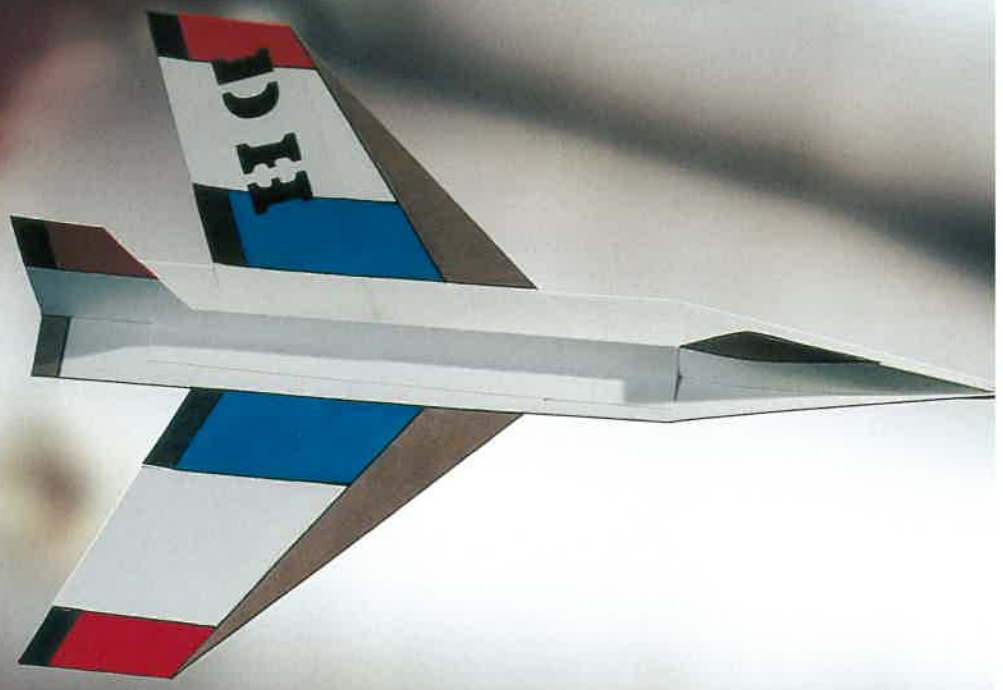
TEP 19 Make a type 1 canopy, using piece C (See p 28). Cut slit in ck of canopy. Apply glue to inside back of canopy and the front tab. p back over vertical tail and front tab into fuselage, as shown.





TEP 20 Measure and cut back of fuselage along heavy line, as own. Adjust dihedral (upward slanting of wings and tail), as shown.

DH108 Swallow



HISTORICAL INFORMATION

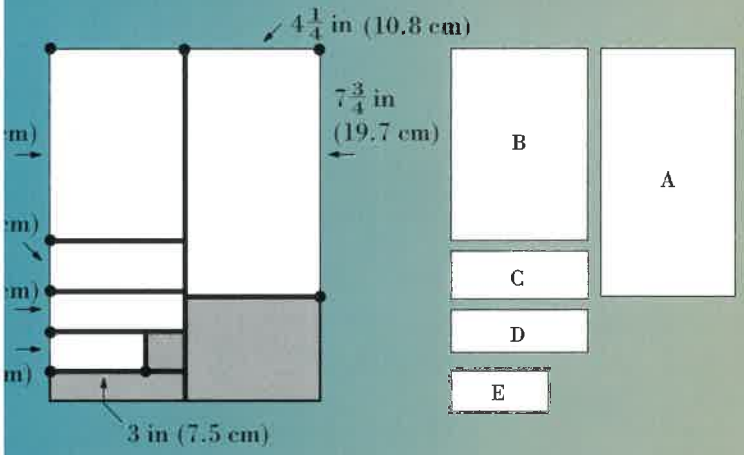
Beyond a certain speed conventional airplanes become less controllable and propellers lose their efficiency. When aircraft approach the speed of sound (about 760 mph) their control becomes unpredictable due to air resistance. For high speed flight a new shape of airplane was needed. For propulsion, designers turned to rockets and jets, which don't need propellers. In the quest for greater speed, Messerschmitt experimented with a rocket propelled airplane during the war, the ME163. After the war, deHavilland used the information gained to build the similar, but jet engined, experimental DH108 Swallow. It had wings that swept back and no horizontal stabilizers. In 1946 it flew over 600 mph. This paper airplane is modeled on the deHavilland Swallow.

Technical Information

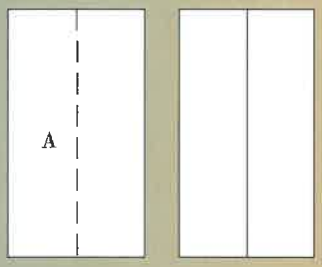
Sweepback: Every increase in speed incr
Below a speed of about 250 mph air mol
move around a well streamlined airplane
speed is increased, however, the molecule
out of the way quickly enough and their
them up into a pressure ridge ahead of th
something like a snowplow pushing snow.
of pressure (drag) makes it difficult to fly
and at the speed of sound it can become
Sweeping the wings back away from the f
making them broader delayed the pressu
until a greater speed was reached. This re
that maintain their efficiency, safely allow
fly faster.

The experimental Swallow was built to te
flight. But even with swept-back wings, w
reached the speed of sound, the pressure
great enough to break the airplane, and i

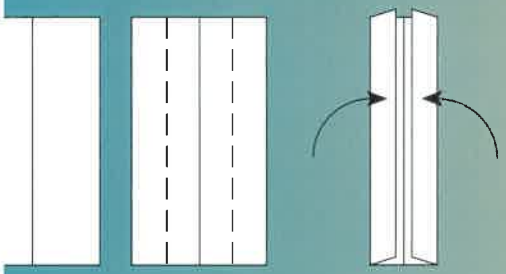
Making the DH 108



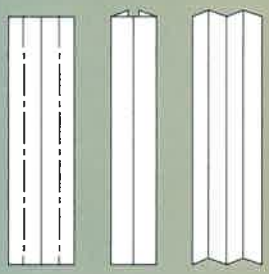
STEP 1 Measure and cut the various pieces, as shown.



STEP 2 Lay piece A flat in a vertical direction. To make the fuselage, fold in half vertically using a valley fold. Unfold.

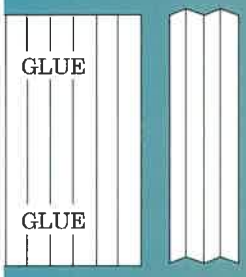


EP 3 Valley fold each outer edge to et center crease, as shown.

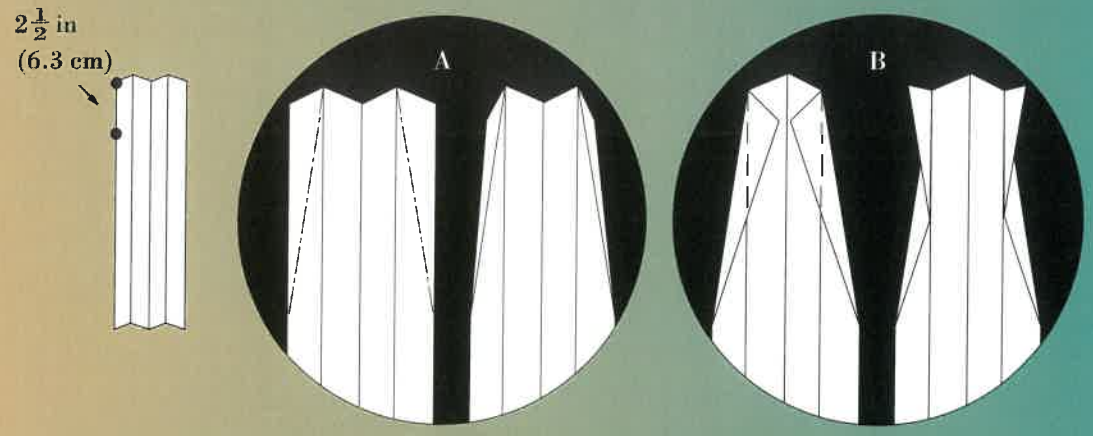


VIEW FROM BACK
(actual size)

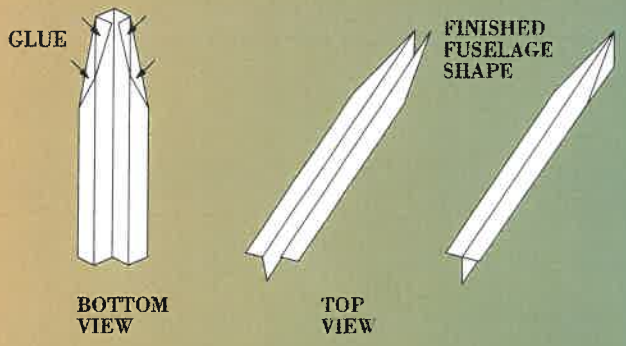
STEP 4 Fold each side again using a mountain fold, so that outer edges meet center crease at back. Then adjust folds so that paper looks like an upside-down W, as shown.



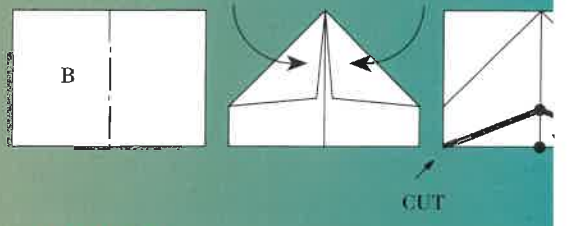
EP 5 Unfold fuselage completely. fold applying glue to all contacting faces, as shown. Make sure fuselage traight.



STEP 6 On each side, measure from top (front of fuselage) and mountain fold along broken lines, as shown in enlarged view A. Then flip over fuselage. On each side, valley fold triangle along broken lines, matching fold line to existing crease, as shown in enlarge view B.



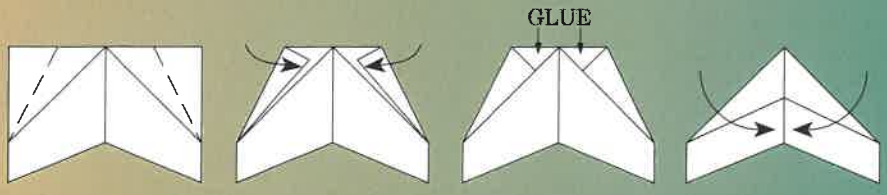
STEP 7 Glue triangles. Hold in place until glue sets. It is important that the fuselage stays straight. Do not glue nose yet.

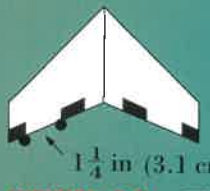


STEP 8 Use piece B to make the wi paper flat in a horizontal direction. M fold in half vertically. Unfold. Then fo side diagonally so that upper edges me crease. Unfold. Measure and cut traili edge, as shown by heavy line.

AILERONS
$\frac{1}{2}$ in x $\frac{1}{4}$ in
(1.3 cm x .6 cm)

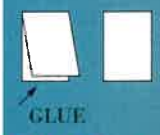
ELEV
$\frac{3}{4}$ in x
(1.9 c

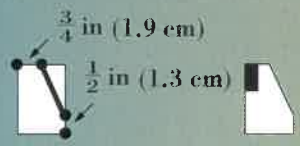




STEP 9 On each side, valley fold diagonally so that outer edge meets previously made diagonal crease. Then apply glue to upper tip only and refold along original diagonal creases.

STEP 10 Flip wing over. On each side, ma ailerons and elevators locations shown.



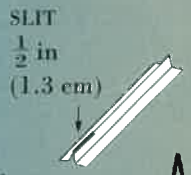


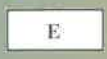
RUDDER
$\frac{3}{4}$ in x $\frac{1}{4}$ in
(1.9 cm x .6 cm)

EP 11 Use piece C to make vertical tail. Lay paper flat in a ical direction. Mountain fold in horizontally. Glue halves ther.

STEP 12 Measure and cut, as shown. Make rudder in locations shown.

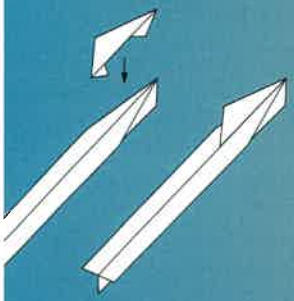
CANOPY (type 2)
$1\frac{3}{8}$ in x 3 in (3.5 cm x 7.5 cm)
Top point 2 in (5 cm)

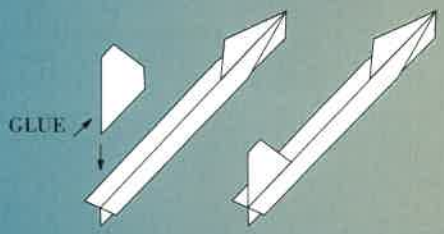


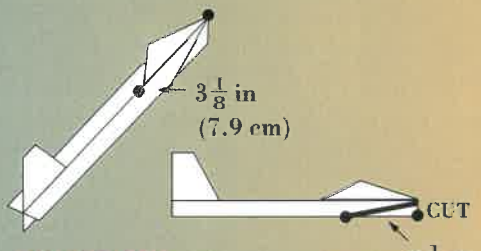


EP 13 Use piece D to make the fuselage Mountain fold in half horizontally. old. Then valley fold so that the outer s meet center crease. Unfold. At one cut slit along center crease, as indicated eavy line. Shape folds as shown.

STEP 14 Use piece E to make the canopy. (See p 28).







EP 15 Apply glue to e of fuselage at the nose and insert tabs on the om of canopy, aligning at ront. Hold until glue sets.

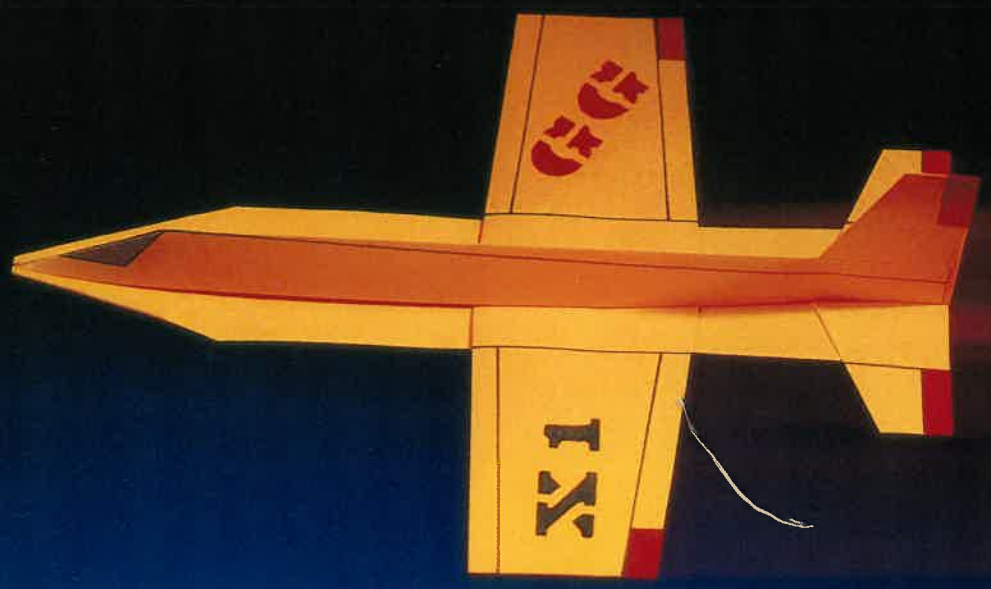
STEP 16 Apply glue to bottom part of vertical tail and insert into back of fuselage, aligning at the back edge.

STEP 17 Measure from front of fuselage and mark where to position wings. Measure and cut nose, as shown by heavy line.

EP 18 Glue wings to fuselage. Then glue top of lage in place so that slit fits around tail and front snuggly over back of canopy.

AIRPLANE NUMBER NINE

X1 Experimental



HISTORICAL INFORMATION

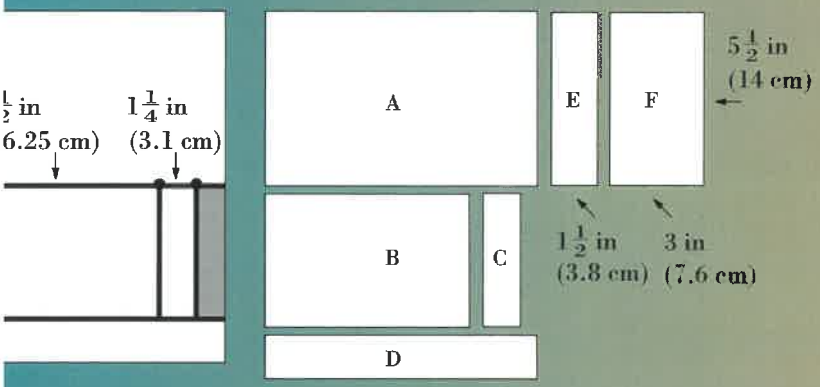
Some people believed that the speed of sound was a barrier that would never be crossed. But designers did not abandon their quest. They shaped an airplane like a 50 caliber bullet, which was known to travel faster than the speed of sound. This experimental plane was the stubby-winged Bell X1. It was called "Glamorous Glennis" after the pilot's wife. While this plane did not have swept-back wings, it successfully "broke the sound barrier" for the first time in 1947. Thus began the building of a long series of X planes used for experiments in ultra high speed and high altitude flight. The X15, for example, flew 8 times the speed of sound to the edge of space at an altitude of 70 miles (112 km) in 1956. This paper airplane is modeled on the Bell X1.

Technical Information

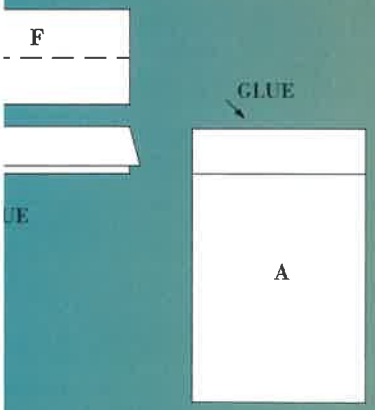
Sound Barrier: What we hear as differe
actually differences in air pressure that
eardrums. These waves of air (called sou
at about 760 mph. An airplane traveling
creates a tremendous pressure ridge bec
air molecules are piled up ahead of its le
What makes it so dangerous is that as sp
the ridge of pressure moves farther back
and begins to affect the control surfaces
the trailing edges. Airplanes that success
than the speed of sound must be designe
pressure is deflected in such a way that it
aircraft control. Thus, their noses are po
wings are thin, and either tapered or swe
planes must also be built strong enough t
pressure. When supersonic airplanes bre
barrier they create a loud booming noise
thunder), as heard from the ground.

The speed of sound is also called Mach 1
speed Mach 2, three times Mach 3, and s
of the scientist Ernst Mach.

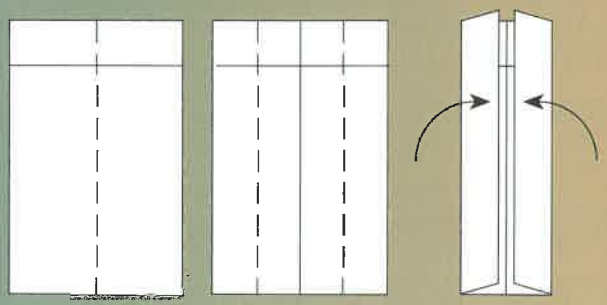
laking the X1



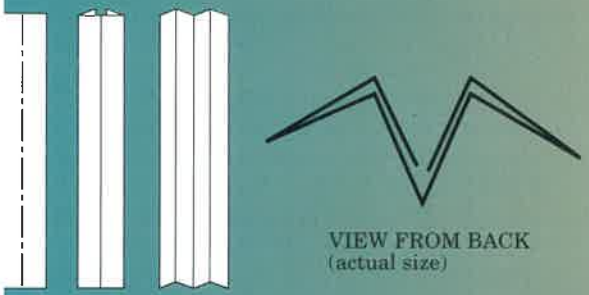
EP 1 Measure and cut the various pieces n a sheet of bond paper, as shown. Two itional pieces E and F are needed, as shown.



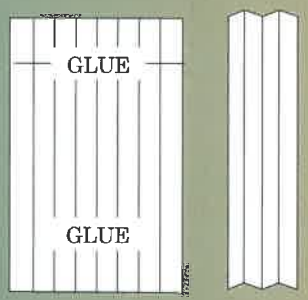
EP 2 Use piece F to make nose ast. Lay flat in a horizontal direction valley fold horizontally. Glue halves ther. Then glue to piece A, as shown.



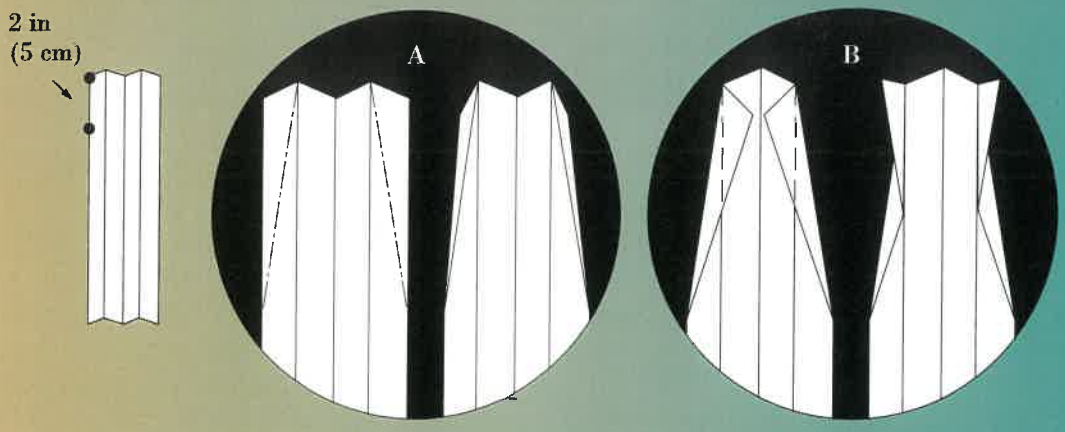
STEP 3 Lay piece A flat in a vertical direction. To make the fuselage, fold in half vertically using a valley fold. Unfold. Then valley fold each side so that outer edges meet center crease, as shown.



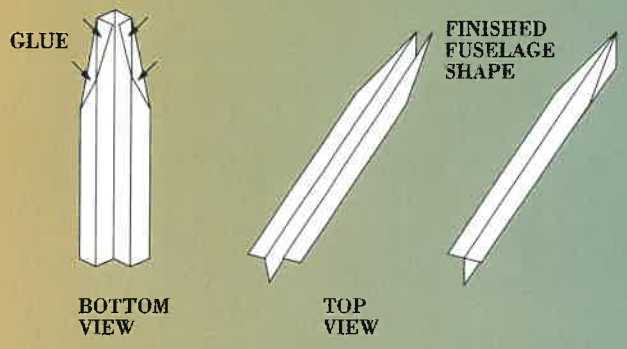
EP 4 Fold each side again using a ntain fold, so that outer edges meet ter crease at back. Then adjust folds so paper looks like an upside-down W, hown.



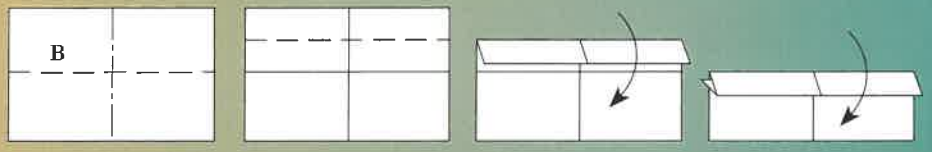
STEP 5 Unfold fuselage completely. Refold applying glue to all contacting surfaces, as shown. Make sure fuselage is straight.



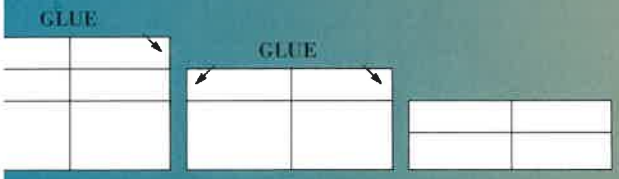
STEP 6 On each side, measure from top (front of fuselage), mark, and mountain fold along broken lines, as shown in enlarged view A. Then flip over fuselage. On each side, valley fold triangle along broken lines, matching fold line to existing crease, as shown in enlarged view B.



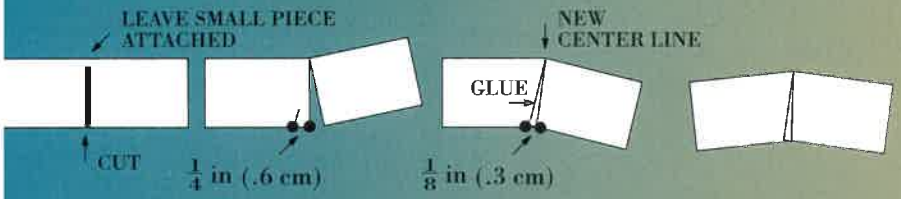
STEP 7 Glue triangles. Hold in place until glue sets. It is important that the fuselage stays straight. Do not glue nose yet.



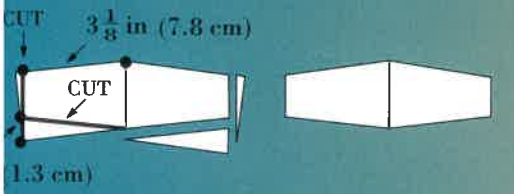
STEP 8 Lay piece B horizontally to make the wings. Fold in half horizontally, using a fold. Unfold. Fold in half vertically, using a mountain fold. Unfold. Then valley fold so tha edge meets center crease. Fold over again along original center crease.



EP 7 Unfold completely. Refold applying glue to no more than 1
2.5) cm) from outer tips, as shown. The folded over part is the
tom of the leading edge (front) of the wings.

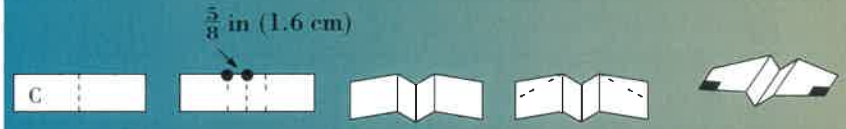


EP 8 To taper wings, cut along center heavy line from trailing edge
ck), leaving a small piece attached at the leading edge. Then measure and
ke a mark on trailing edge, as shown. Align pieces to the mark. Glue.
asure and draw a new center line.



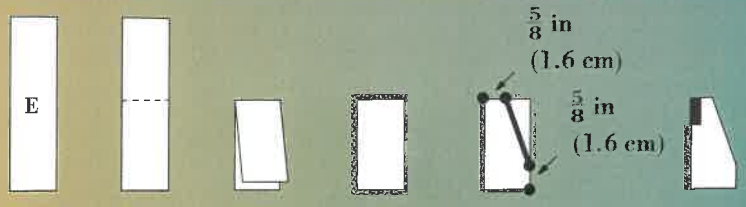
AILERONS
$\frac{1}{2}$ in x $\frac{1}{4}$ in
(1.3 cm x .6 cm)

EP 9 On each side, measure and cut, as indicated by heavy lines. On the
iling edges of wingtips, make ailerons.



ELEVATORS
$\frac{3}{4}$ in x $\frac{1}{4}$ in
(1.9 cm x .6 cm)

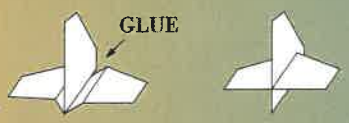
EP 10 Use piece C to make the horizontal tail. Valley fold in half vertically. Unfold.
each side, measure from center crease, as shown, and mountain fold. On each side,
asure and mountain fold leading edge along broken lines. Glue. Make elevators on trailing
es.

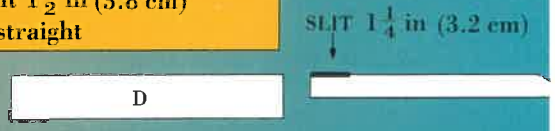


RUDDER
$\frac{3}{4}$ in x $\frac{1}{4}$ in
(1.9 cm x .6 cm)

STEP 11 Lay piece E vertically to make the vertical tail. Valley fold in half horizontally and glue halves together. Measure and cut along heavy line, as shown. Make rudder on trailing edge.

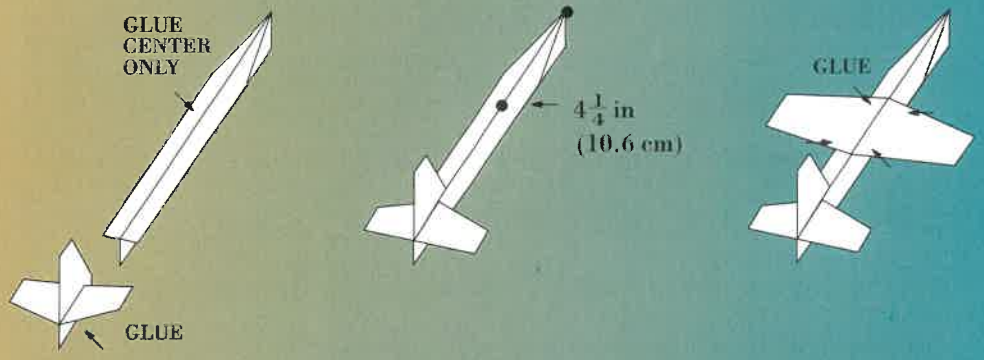
CANOPY (type 1)
$1\frac{1}{4}$ in x $8\frac{1}{2}$ in (3.1 cm x 21.7 cm)
Top point $1\frac{1}{2}$ in (3.8 cm)
Back is straight



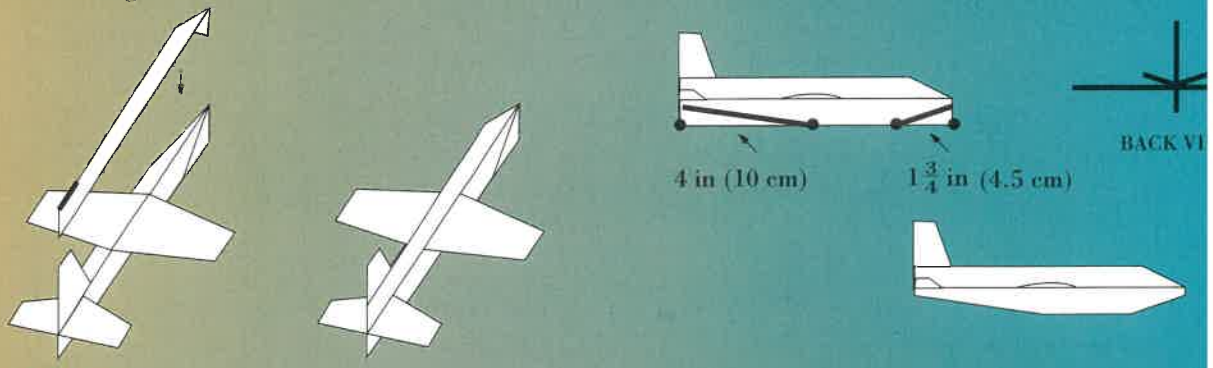


STEP 12 Finish the tail. Apply glue to inside of horizontal tail and slide vertical tail in place, aligning at trailing edge.

STEP 13 Use piece D to make the can (see p 28). Make slit in the back of canopy



STEP 14 Apply glue to inside center only of fuselage. Then apply glue and slide tail i fuselage, aligning at trailing edge. Measure from front and mark for wing position. Glue w to fuselage.



STEP 15 Apply glue to inside back of canopy and front tab of canopy. Insert tab into f The vertical tail fits into slit. Align at nose. To finish, measure and cut front and back of along heavy diagonal lines, as shown. Adjust dihedral (upward slanting of wings and tail

Mirage 2000

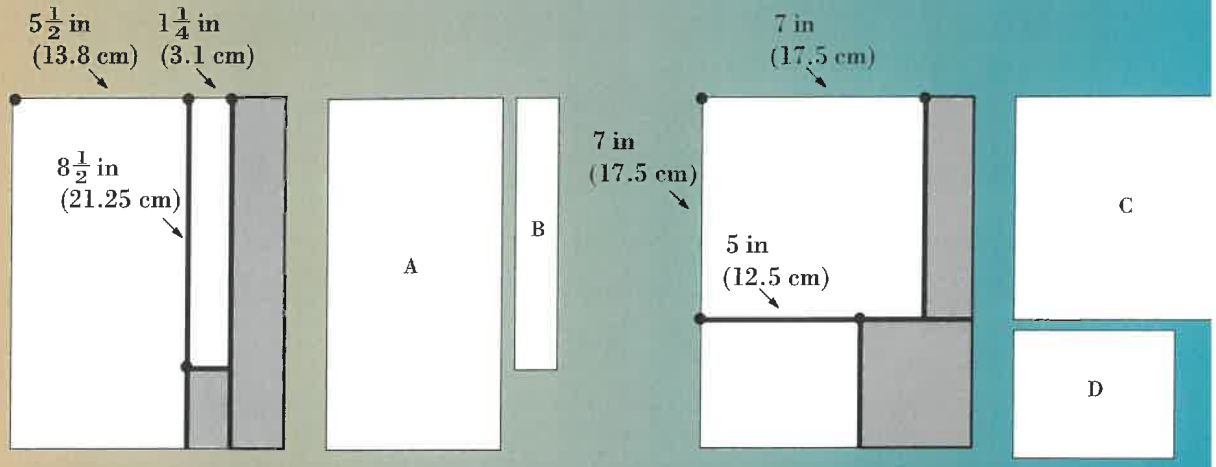
AL INFORMATION

l flight became common after World War
gs that swept back came into widespread
e of their efficiency at high speed. Filling
e between the wingtips of swept-back
lted in the formation of triangle shaped
a wings). Delta wings are very stable in
re good for supersonic flight. One of
uccessful applications was in the early
e experimental Fairey Delta that
000 mph. Two other supersonic planes
s were the General Dynamics F106 Delta
he Dassault-Breguet Mirage 3. The
been upgraded several times and is still
as the Mirage 2000. This paper airplane
on it.

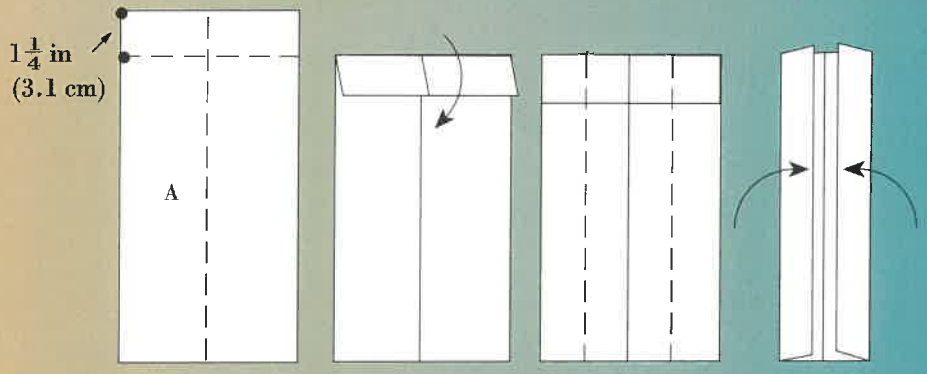
Technical Information

Delta Wings: The triangle shape of these wings has a unique affect on the air flowing over their upper surfaces. The air flows diagonally towards the fuselage. Like swept-back wings, delta wings prevent the buildup of the pressure ridge created by high speed flight. In addition, the shape lends added stability, and most delta wing airplanes need no additional horizontal stabilizers. However, because they are so stable, some fighter planes have surfaces added to make them less stable and more maneuverable. Delta wings can operate at much greater angles of attack before the air flowing over the top surfaces becomes turbulent and the wings stall.

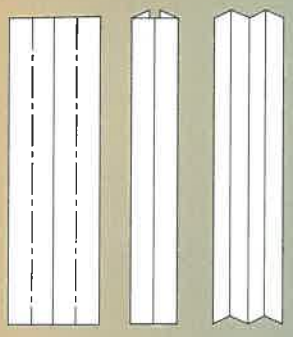
Making the Mirage

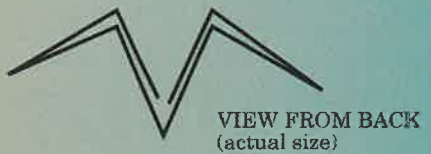


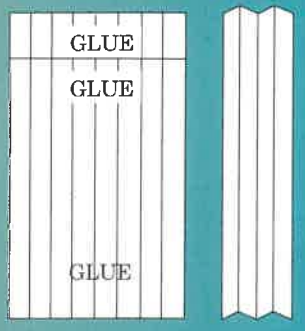
STEP 1 Measure and cut the various pieces from two sheets of bond paper.



STEP 2 Lay piece A vertically to make the fuselage. Fold in half vertically using a valley fold. Unfold. Measure from top and valley fold, as shown. Valley fold each side so that outer edges meet center crease, as shown.

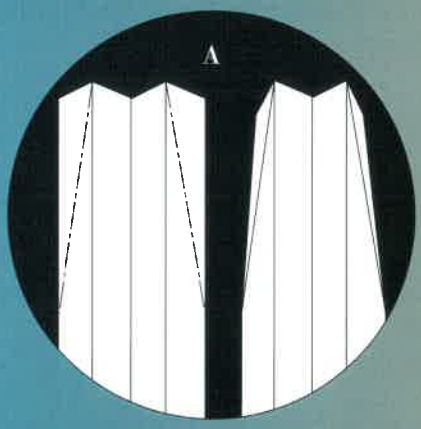


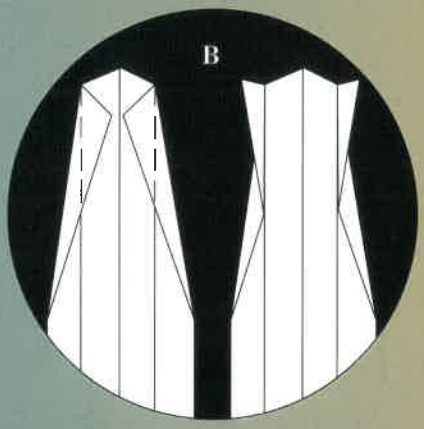




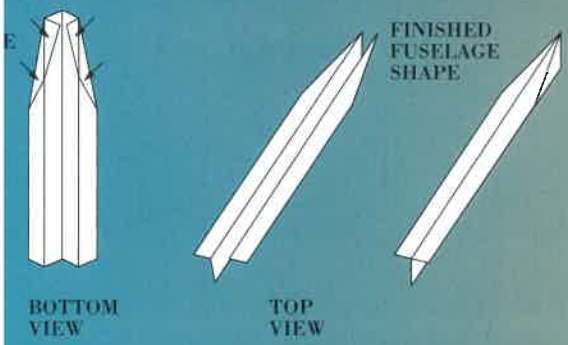
STEP 3 Fold each side again using a mountain fold, so that outer edges meet center crease at back. Then adjust folds so that paper looks like an upside-down W, as shown.

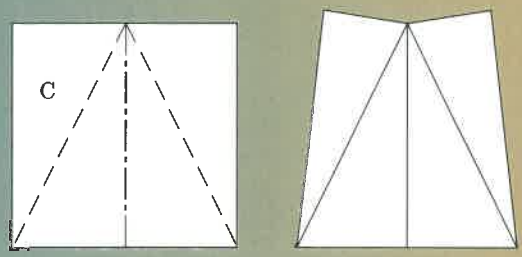
STEP 4 Unfold fuselage completely. Refold, applying contacting surfaces, as shown sure fuselage is straight.





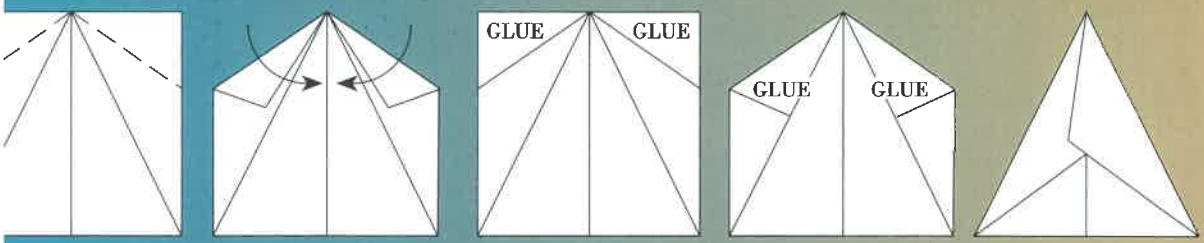
EP 5 On each side, measure from top (front of fuselage), mark, and mountain fold ng broken lines, as shown in enlarged view A. Then flip over fuselage. On each side, ey fold triangle along broken lines, matching fold line to existing crease, as shown in arged view B.





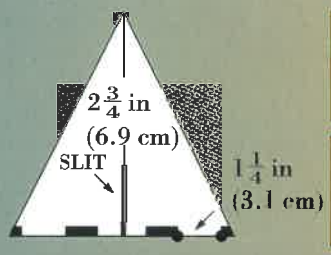
TEP 6 Glue triangles. Hold in place til glue sets. It is important that the selage stays straight. Do not glue nose t.

STEP 7 Use piece C to make the wings. Mountain fold in half vertically. Unfold. Draw a line from the top center to the lower corners and valley fold along lines, as shown. Unfold.



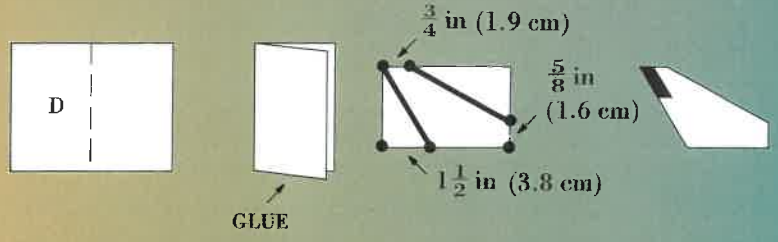
EP 8 On each side, valley fold so that top e meets the diagonal crease.

EP 9 Unfold completely. Refold, applying glue oth sides of small upper triangles only. Flip over finish wings. Add ailerons and elevators, in tions shown. Make slit, as shown by heavy line.



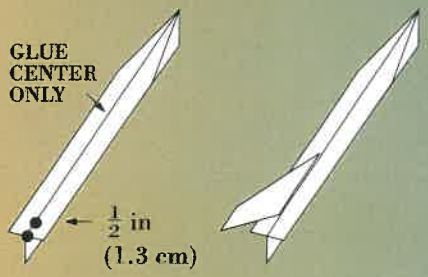
AILERONS
$\frac{1}{2}$ in x $\frac{1}{4}$ in
(1.3 cm x .6 cm)

ELEVATORS
1 in x $\frac{1}{4}$ in
(2.5 cm x .6 cm)

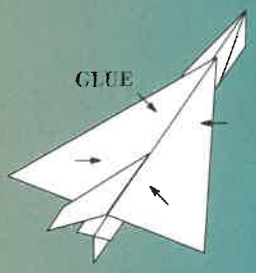


RUDDER
1 in x $\frac{1}{4}$ in
(2.5 cm x .6 cm)

STEP 10 Lay piece D horizontally to make the vertical tail. Valley fold in half vertica Glue halves together. Turn, as shown, measure, mark, and cut along heavy lines. Make r on trailing edge, as shown.

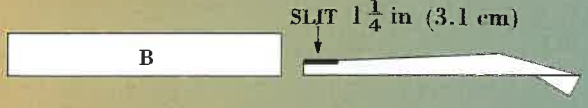


STEP 11 Apply glue to inside center only of fuselage. Measure from back of fuselage and mark, as shown. Then apply glue and slide tail into fuselage, aligning at mark.

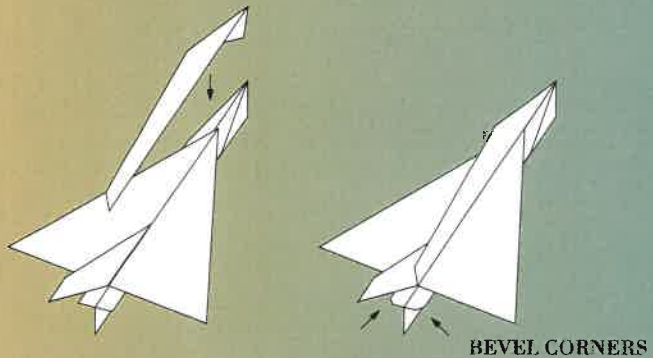


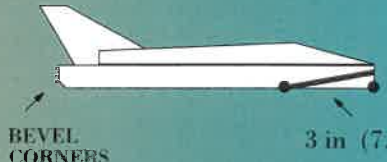
STEP 12 Apply glue and attach wings t fuselage, slipping around vertical tail. Alig trailing edge at the mark.

CANOPY (type 1)
1 $\frac{1}{4}$ in x 8 $\frac{1}{2}$ in (3.1 cm x 21.7 cm)
Top point 3 in (7.5 cm)
Back $\frac{3}{8}$ in (1 cm)



STEP 13 Use piece B to make canopy (see p 28). Make a slit at center back of canopy.





STEP 14 Apply glue to inside back of canopy and front tab of canopy. Insert tab int fuselage. The vertical tail fits into slit. Align at nose. Measure and cut front of fuselage a heavy diagonal line, as shown. To finish, bevel all corners on fuselage back, as shown.

Lifting Body

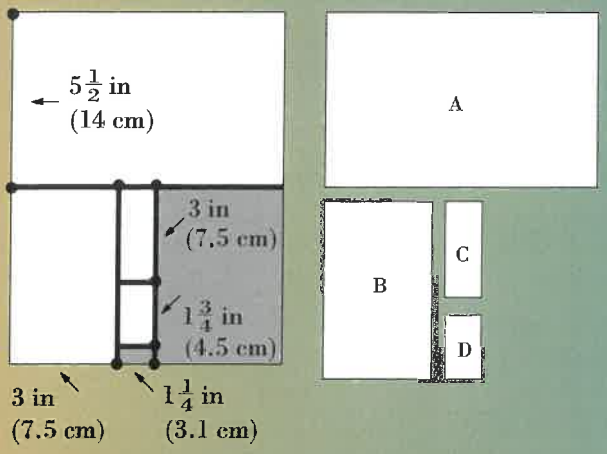
CAL INFORMATION

0s experiments were conducted into airplanes with flattened and widened o that these became lift-producing. This r much smaller wings. Among these s the American built X20 Dyna-Soar. re the Soviet built Cosmos series of at were actually rocketed into space. All body research planes were used to study l gliding (therefore the word "soar" in ame). The information gathered was arily in developing space vehicles. This lane is modeled on the lifting-body lanes.

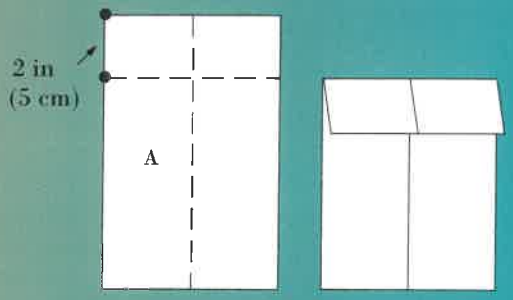
Technical Information

Lifting Bodies: The lifting-body research airplanes were not intended for operational use. They were used to demonstrate that wedge-shaped airplanes with very stubby wings could actually fly. Having small wings is important in an airplane that is to be rocketed into space orbit at high speed. Large wings could not stand the stress and would rip off. The angle of attack is very important in the flight of these planes, and is greater than in most airplanes. Because their wings are so small, these planes are roll-unstable. Some experimental planes rocked back and forth wildly in flight. This problem was eventually solved. One successful application of lifting-body research is the Space Shuttle. On its return from space orbit, the shuttle is the world's heaviest and fastest glider.

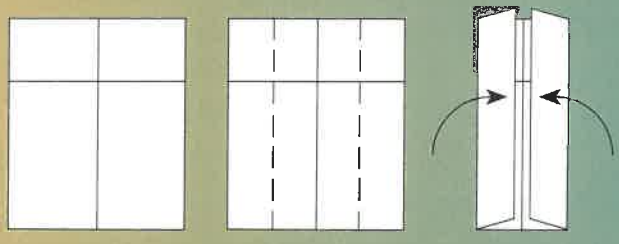
Making the Lifting Body



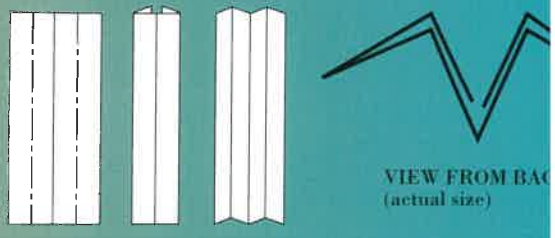
STEP 1 Measure and cut the various pieces from a sheet of bond paper, as shown.



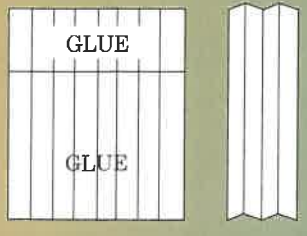
STEP 2 Lay piece A flat in a vertical direction. To make the fuselage, fold in half vertically using a valley fold. Unfold. Measure from top and valley fo as shown.



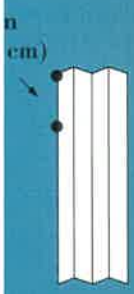
STEP 3 Valley fold each side so that outer edges meet center crease, as shown.

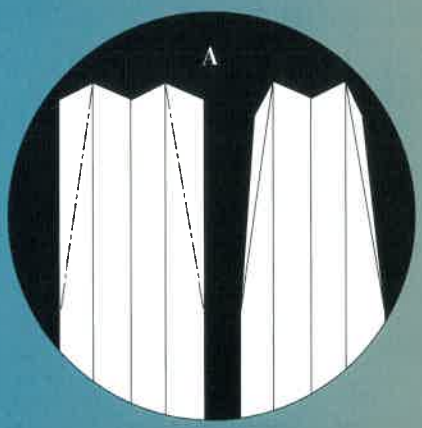


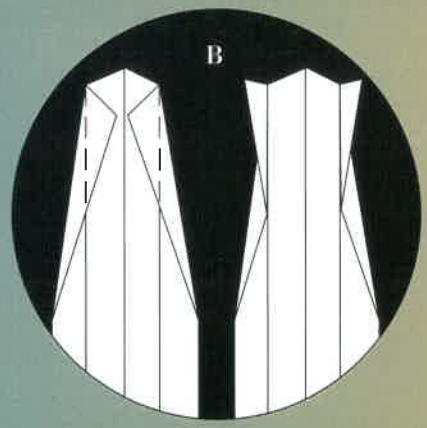
STEP 4 Fold each side again using a mountain fold, so that outer edges meet crease at back. Then adjust folds so that looks like an upside-down W, as shown.



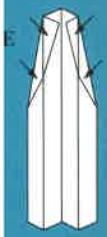
STEP 5 Unfold fuselage completely. Refold applying glue to all contacting surfaces, as shown. Make sure fuselage is straight.



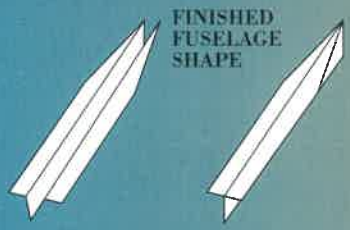




EP 6 On each side, measure from top (front of fuselage), mark, and mountain fold ıg broken lines, as shown in enlarged view A. Then flip over fuselage. On each side, ey fold triangle along broken lines, matching fold line to existing crease, as shown in ırged view B.

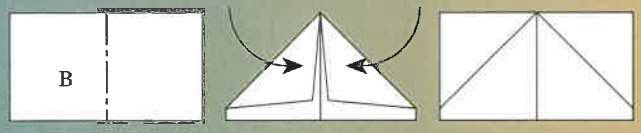


BOTTOM VIEW



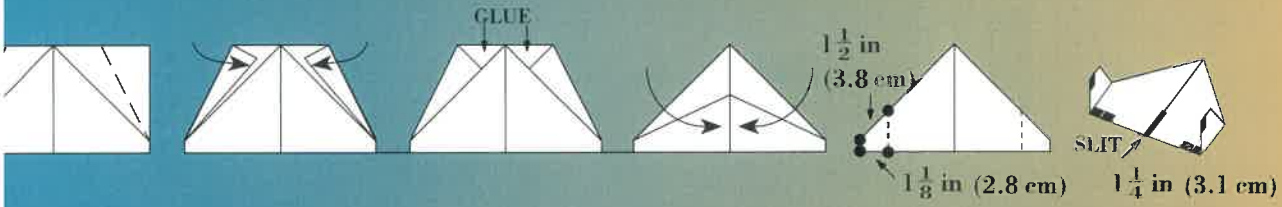
TOP VIEW

EP 7 Glue triangles. Hold in ace until glue sets. It is important at the fuselage stays straight. Do not ıe nose yet.



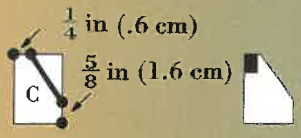
STEP 8 Use piece B to make the wings. Lay paper flat in a horizontal direction. Mountain fold in half vertically. Unfold. Then fold each side diagonally so that upper edges meet center crease. Unfold.

RUDDERS	AILERONS	ELEVATORS
$\frac{3}{8}$ in x $\frac{1}{4}$ in (1 cm x .6 cm)	$\frac{3}{8}$ in x $\frac{1}{4}$ in (1 cm x .6 cm)	$\frac{3}{8}$ in x $\frac{1}{4}$ in (1 cm x .6 cm)



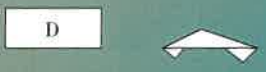
EP 9 On each side, valley fold diagonally so that er edge meets previously made diagonal crease. Then ly glue to upper tip only and refold along original gonal creases. Flip wings over. On each side, measure l valley fold wingtips to make vertical tails.

STEP 10 Make a slit at the center back of wings, as shown. Make rudders, ailerons, and elevators in locations shown.



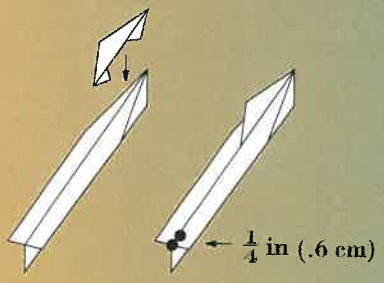
RUDDER
$\frac{3}{8}$ in x $\frac{1}{4}$ in
(1 cm x .6 cm)

CANOPY (type 2)
$1\frac{1}{4}$ in x 3 in (3.1 cm x 7.5 cm)
Top point 2 in (5 cm)

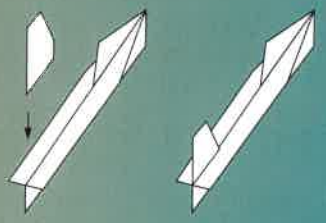


STEP 11 Use piece C to make a center vertical tail. Measure and cut, as shown. Make rudder in location shown.

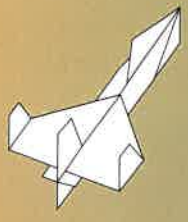
STEP 12 Use piece D to make the canopy. (See p 28).

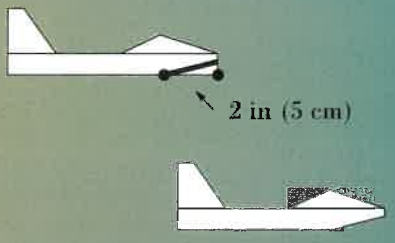


STEP 13 Applying glue to inside of fuselage at the nose end, insert tabs on the bottom of canopy, aligning at front. Measure from back of fuselage and mark wing position.



STEP 14 Applying glue to bottom part of vertical tail, insert into back of fuselage, aligning at back edge.





STEP 15 Glue wings to fuselage. Align trailing (back) edge to the mark so that slit fits around center vertical tail.

STEP 16 Measure from front of fuselage and cut nose, as shown by heavy diagonal line. Adjust vertical tails to be vertical.

Glider

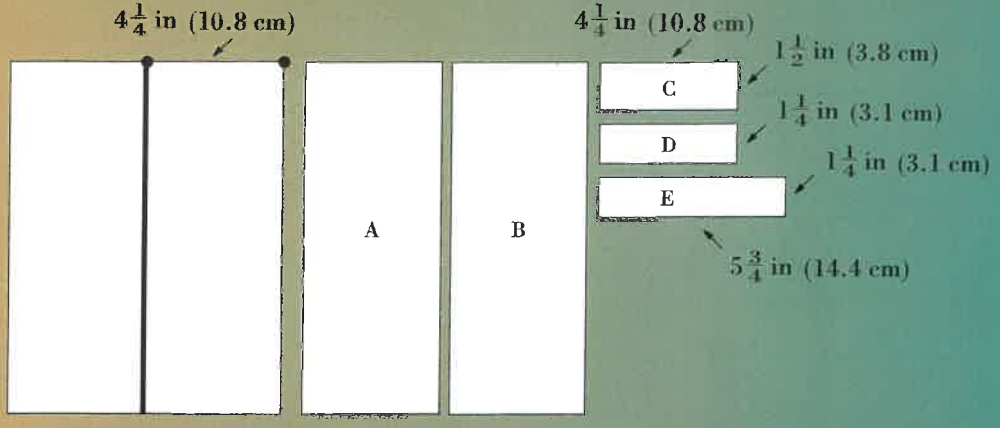
CAL INFORMATION

ber Wright was mainly interested in
light, his brother Orville experimented
s. Both types of flight continued to be
. By the time World War II ended much
earned about good aerodynamic
ice. During the 1950s and 60s the design
was greatly improved as builders
low-drag gliders with highly efficient
h long soaring flights now possible,
ream of sustained motorless flight was
n Europe, Germany became well known
ers. In the USA, the Schweizer brothers
rk built good training gliders that did
romote gliding in North America.
came a popular sport the world over.
r airplane is modeled on gliders.

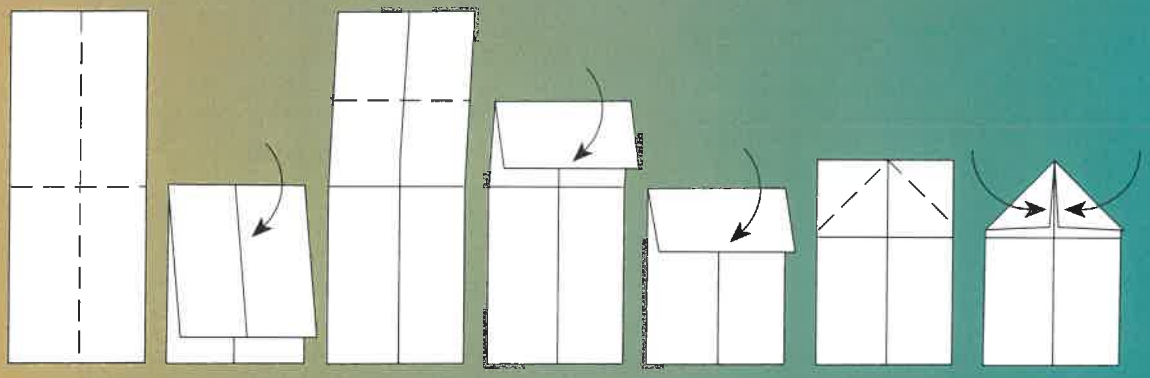
Technical Information

Aspect Ratio: Wings that are short, like the ones found on the X1 and the Lifting Body, have a low aspect ratio. Wings that are long and slender have a high aspect ratio. Wings with a high aspect ratio produce more lift for the amount of drag they create. This makes them suitable for gliders, where the smallest amount of drag possible is best. Today's gliders are very efficient. They soar like the eagles. From an altitude of 6000 ft (1800 m) some of them can fly about 60 nautical miles forward without any additional lift. To gain altitude, pilots usually take advantage of columns of rising air. (This is air that has been warmed by the ground on a sunny day, making it lighter and consequently making it rise.) Some glider pilots have remained airborne for more than ten hours and flown distances of more than 1000 nautical miles without landing. They have reached altitudes of more than 40,000 ft (12,000 m). Because the columns of rising air are invisible, it takes skill, and sometimes luck, to find and stay in them. Many countries have national gliding competitions where the best pilots demonstrate their skills.

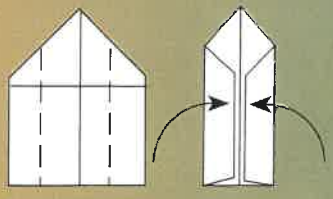
Making the Glider



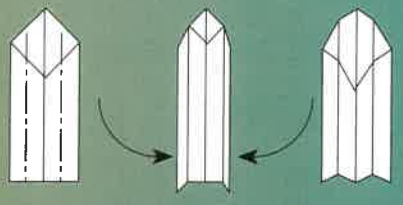
STEP 1 Measure and cut a sheet of bond paper, as shown. Three additional pieces are needed, as shown.



STEP 2 To make the fuselage, fold piece A in half vertically using a valley fold. Unfold. Valley fold in half horizontally. Unfold. Then valley fold so that upper edge meets horizontal crease. Refold original horizontal crease. Then on each side, valley fold diagonally so that top edge meets center crease.

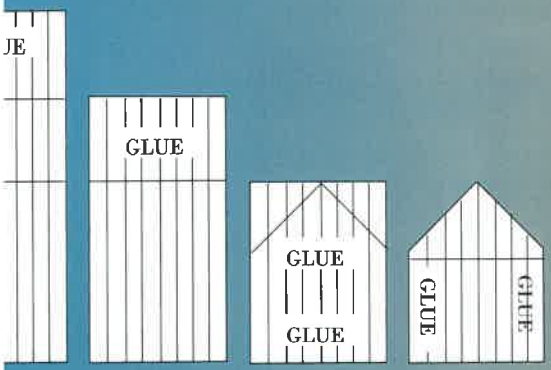


STEP 3 Valley fold each side so that outer edges meet center crease, as shown.

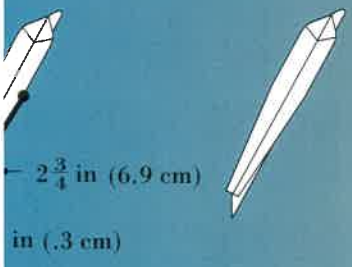


VIEW FROM BACK
(actual size)

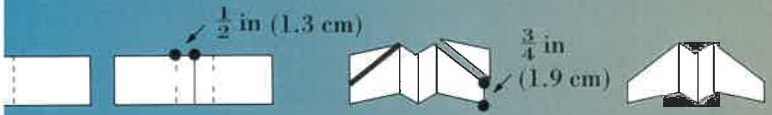
STEP 4 Fold again using a mountain fold, so that outer edges meet center crease at back. Then adjust folds so that paper looks like an upside-dow W, as shown.



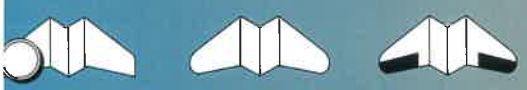
P 5 Unfold fuselage completely. Refold, ving glue to contacting surfaces, as shown. e sure fuselage is straight.



P 7 On each side, measure ut fuselage back, as shown by lines.

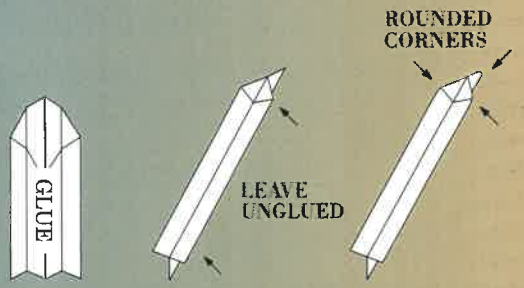


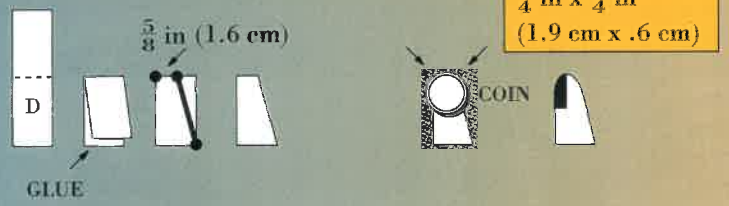
P 9 Use piece C to make the horizontal tail. Valley fold in half vertically. old. On each side, measure from center crease, as shown, and mountain fold. ach side, measure and cut leading edges along heavy lines, as shown.



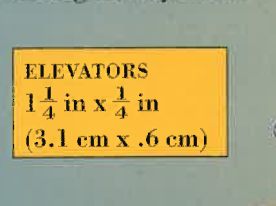
P 10 Trace around a coin and ut to make all the corners rounded 26). On trailing edges, make tors.

STEP 6 Glue center of fuselage, leaving 1 in (2.5 cm) at the nose and 1 in (2.5 cm) at the tail end unglued. Round corners at nose end.

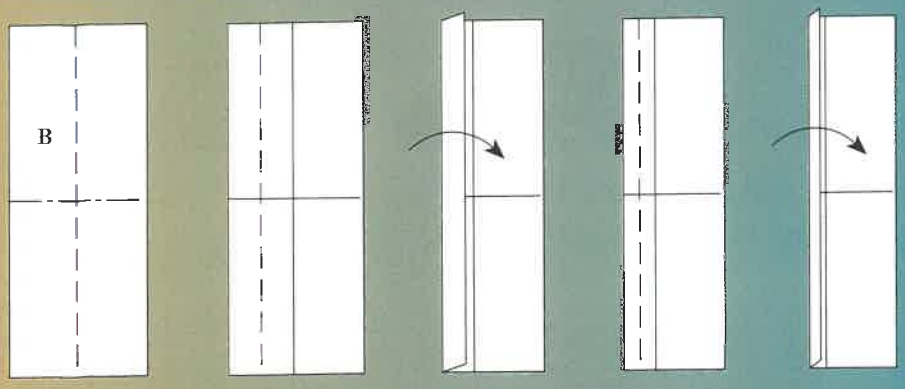




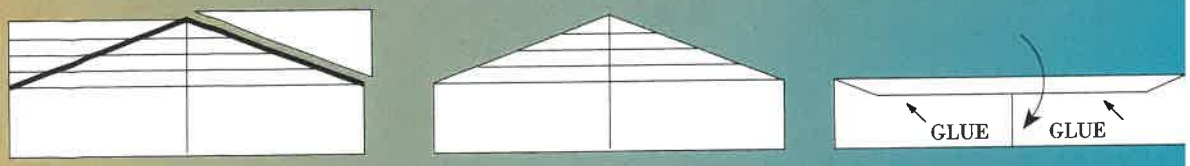
STEP 8 Lay piece D vertically to make the vertical tail. Valley fold in half horizontally. Glue halves together. Measure and cut leading edge along heavy line, as shown. Trace around a coin and cut out to round corners (see p 26). On trailing edge, make rudder.



STEP 11 Apply glue to inside of horizontal tail and insert vertical tail, aligning trailing edges.

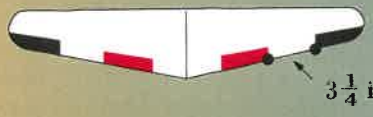


STEP 12 Use piece B to make the wings. Fold in half horizontally, using a mountain fold. Unfold. Fold in half vertically, using a valley fold. Unfold. Then valley fold so that outer edge meets center crease. Fold same side again so that outer edge again meets center crease. Refold original horizontal center crease.



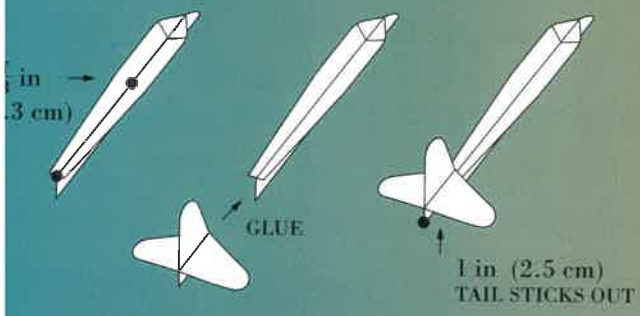
STEP 13 Unfold completely. On each side, draw and cut diagonally along heavy lines, as shown. Refold. Apply glue before refolding original horizontal center crease only. The folded over part is the bottom of the leading edge (front) of the wings. These slender wings are quite fragile. When they are completed, make sure they are not twisted.

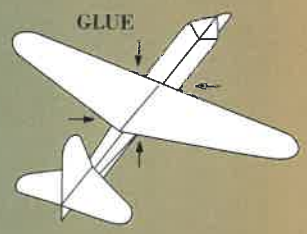
STEP 14 Measure and cut trailing edge (back) of wings, as shown by heavy lines. Then trace around a coin and cut out to make rounded corners at both leading edges and trailing edges, as shown (see p 26).



AILERONS	FLAPS
$\frac{3}{4}$ in x $\frac{1}{4}$ in	$1\frac{1}{4}$ in x $\frac{1}{4}$ in
(1.9 cm x .6 cm)	(3.1 cm x .6 cm)

STEP 15 At wingtips on trailing edges, make ailerons. Then make secondary control surfaces (flaps), in locations shown.

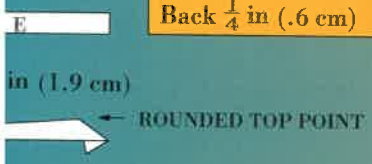


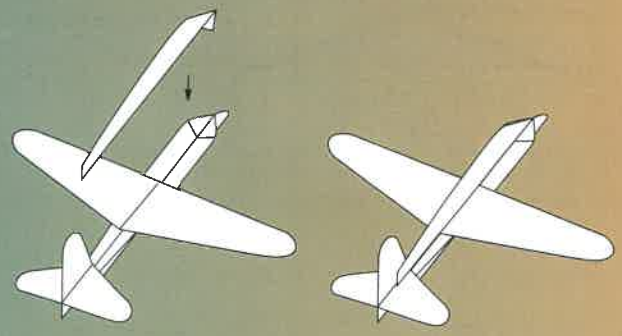


P 16 Measure from back of fuselage and mark on of leading edge (front) of wing. Apply glue lide tail into back of fuselage.

STEP 17 At the mark, attach wings to fuselage.

CANOPY (type 1)
$1\frac{1}{4}$ in x $5\frac{3}{4}$ in (3.1 cm x 14.6 cm)
Top point 1 in (2.5 cm)
Back $\frac{1}{4}$ in (.6 cm)





P 18 Make the canopy, using piece E 28). Make a slit at the center back, as . Round the top point slightly.

STEP 19 Apply glue to inside back and front tab of canopy. Insert tab into fuselage, sliding vertical tail into slit. Align at nose.

P 20 Measure and cut back of fuselage along heavy diagonal line, as shown. dihedral (upward slanting of wings and tail), as shown.

F16 Falcon

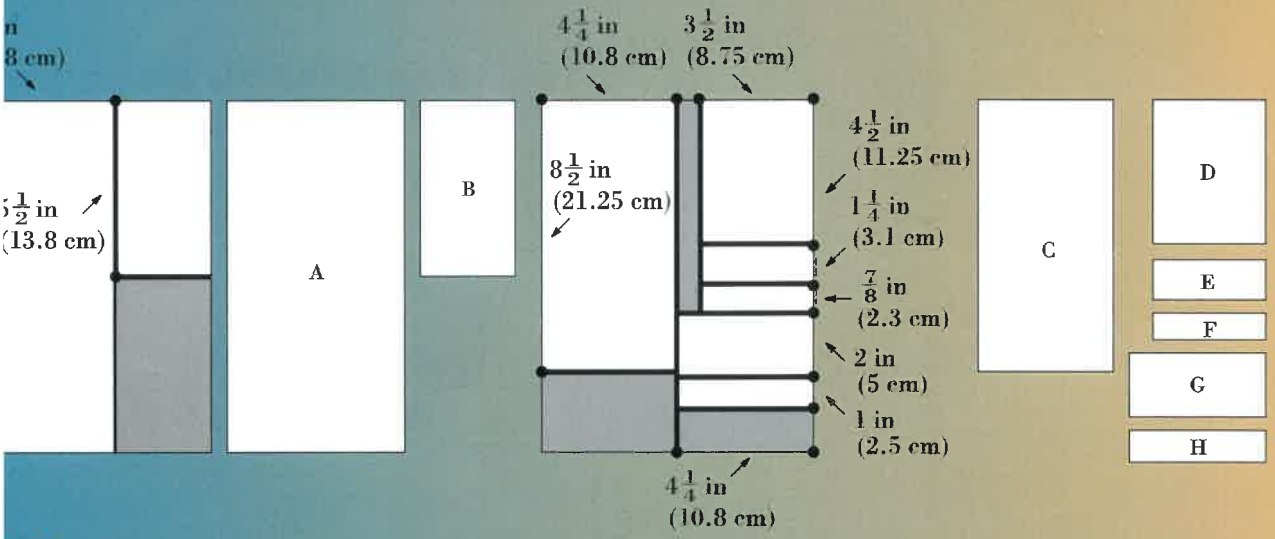
HISTORICAL INFORMATION

In the early 1970s the General Dynamics F16 was an experimental airplane used to test new lightweight materials and computer technology. Since then it has become one of the most maneuverable and versatile fighter planes ever made, and is used for a wide range of military tasks. It can be found in the air forces of at least ten countries. Its ailerons, elevators, and rudder, as well as navigation and weapons systems, are controlled by computer. The plane has modified delta wings with a conventional tail. For added stability it has a pair of canted (slanted) ventral fins beneath the horizontal stabilizers. It is commonly called the "Falcon". This paper airplane in modeled on the F16.

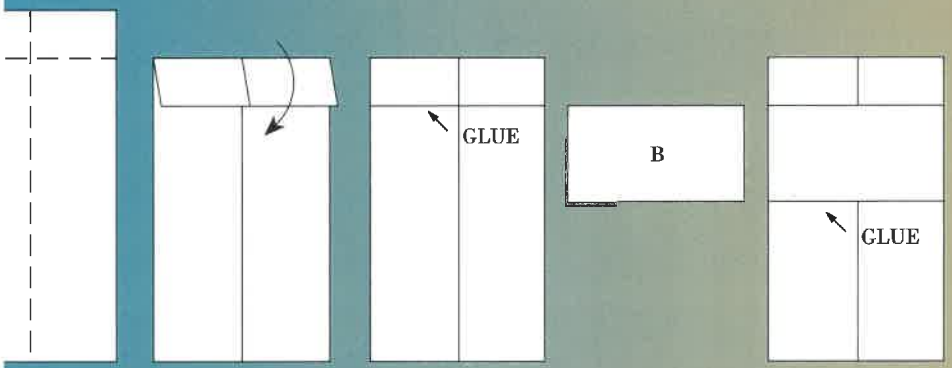
Technical Information

The F16 has a flattened fuselage, some
body. While the wings of this plane are
triangular, they attach to the fuselage
on the leading edges called strakes. Th
flight characteristics of the plane at ve
high speeds. In this paper model the fl
acts as part of the leading edge extens
has a single turbojet engine with an aft
fly twice the speed of sound at an altitu
(18,000 m). Its air intake is situated i
canopy underneath the fuselage. The
improved fuel efficiency over older jet
a missile rail at each wingtip, and can
tanks as well as a variety of armament
This makes it useful for both air-to-air a
military operations. Besides its military
is also used as an aerial display plane a

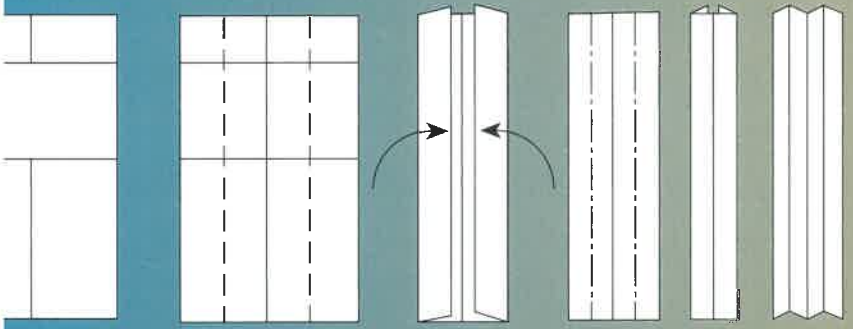
aking the F16



P 1 Measure and cut the various pieces from two sheets of bond paper, as shown.

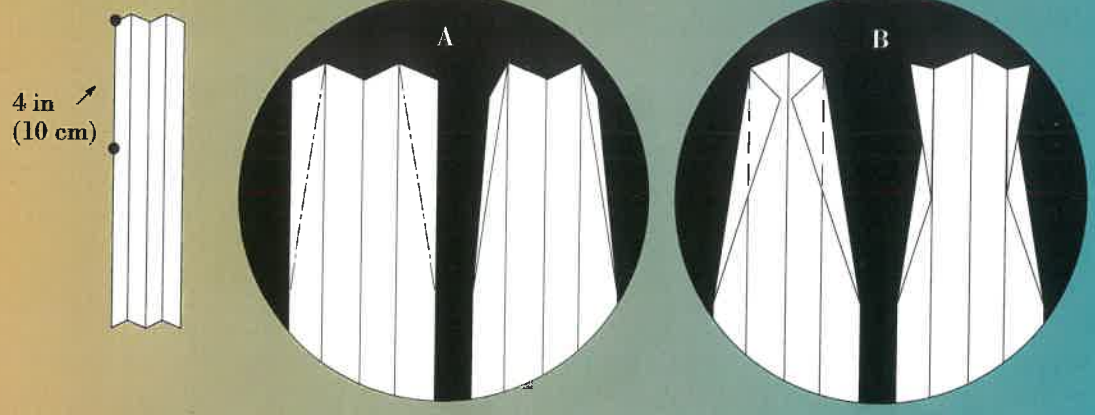


P 2 Lay piece A flat in a vertical direction. To make the fuselage, fold in half vertically a valley fold. Unfold. Measure and valley fold horizontally, as shown. Glue this flap down. glue piece B in place, aligning against the glued-down flap, as shown.

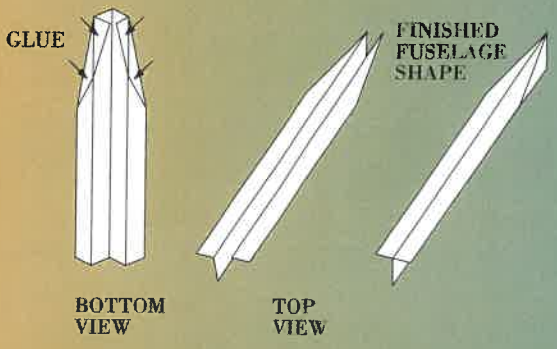


VIEW FROM BACK
(actual size)

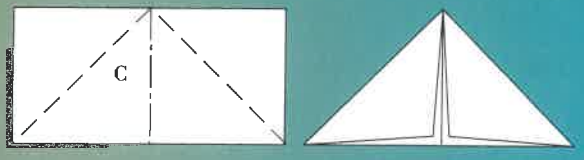
P 3 Refold in half vertically using a valley fold. Unfold. Valley fold each side so the outer edges meet center crease, as shown. Fold each side again using a mountain so that outer edges meet center crease at back. Then adjust folds so that paper s like an upside-down W, as shown.



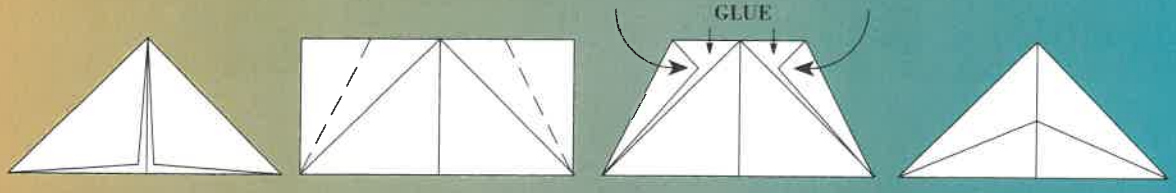
STEP 4 On each side, measure from top (front of fuselage), mark, and mountain fold along broken lines, as shown in enlarged view A. Then flip over fuselage. On each side, valley fold triangle along broken lines, matching fold line to existing crease, as shown in enlarged view B.



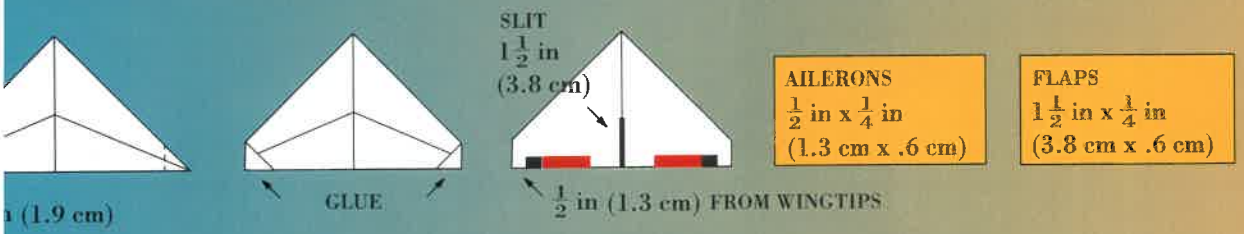
STEP 5 Glue triangles. Hold in place until glue sets. It is important that the fuselage stays straight. Do not glue nose yet.



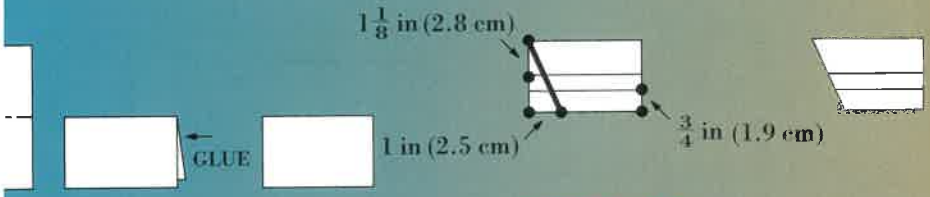
STEP 6 Use piece C to make the wings. Fold i half vertically, using a mountain fold. Unfold. O each side, valley fold diagonally so that top edge meets center crease, as shown.



STEP 7 Unfold diagonal folds. On each side, valley fold diagonally so that outer edges meet diagonal crease, as shown. Apply glue to small upper triangles only and refold original diagonal creases.



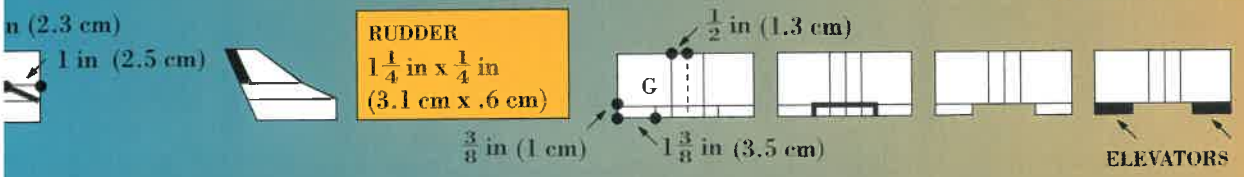
P 8 At each wingtip, measure and valley fold, as shown. Glue down the small les. Flip over and make ailerons and flaps in locations shown. At the trailing make a slit along the center crease.



P 9 Mountain fold piece D horizontally to make the al tail. Glue halves together.

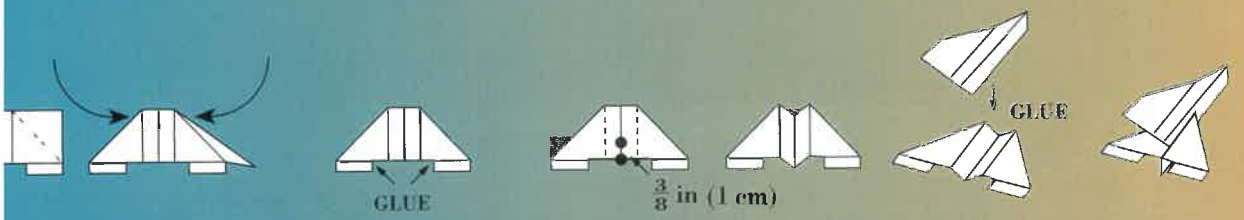
STEP 10 Measure and draw lines, as shown. Cut diagonally, as shown by heavy lines.

ELEVATORS
1 3/8 in x 3/8 in
(3.5 cm x 1 cm)



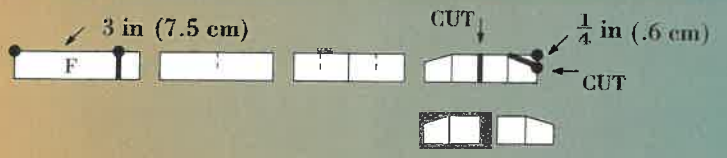
P 11 Measure and draw ional lines to make leading as shown. Cut diagonally, as by heavy lines. Add rudder.

STEP 12 Use piece G to make horizontal tail. Valley fold in half vertically. Unfold. On each side, measure and draw lines. To make elevators, cut out piece, as shown by heavy lines.



P 13 On each side, mountain iagonally so that upper edge vertical crease, as shown. Glue.

STEP 14 Measure from back and make a mark. On each side, mountain fold along lines, as shown. Apply glue to inside of horizontal tail and isert vertical tail, aligning trailing edge (back) to the mark.

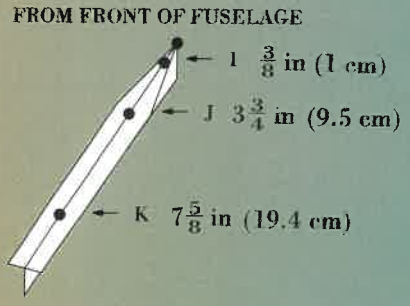


CANOPY (type 2)
$1\frac{1}{4}$ in x $3\frac{1}{2}$ in (3.
Top point 2 in (5

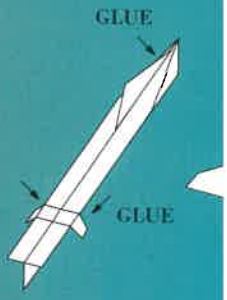
STEP 15 Cut piece F to size for the ventral fins, as shown. Mountain fold in half vertically. Unfold. On each side, mountain fold in half vertically so that outer edge meets center crease. Unfold. On each side, measure and cut, as shown by heavy line. Then cut in two along center crease.

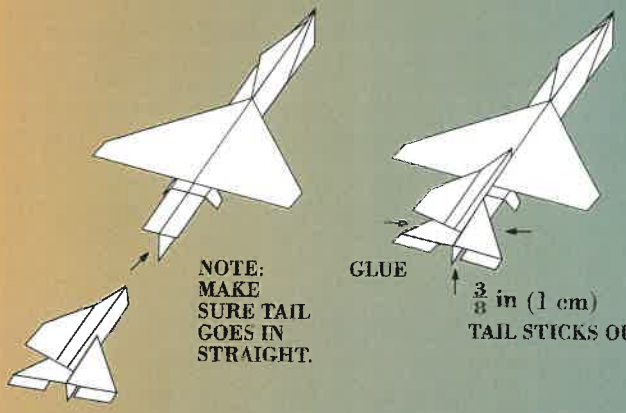
STEP 16 Use piece E to make the canopy. (See p 28.)

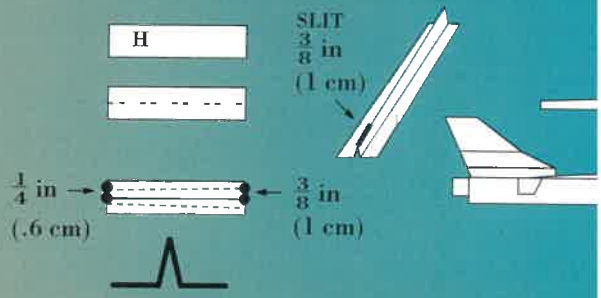
STEP 17 Measure from front of fuselage and make marks for positioning the leading edges of canopy at I, wings at J, ventral fins at K.



STEP 18 Apply glue to inside of nose and the small tabs on the bottom of the canopy. Slide canopy in place. Hold until glue sets. Next, glue ventral fins in place. Then glue wings in place overlapping ventral fins, as shown.

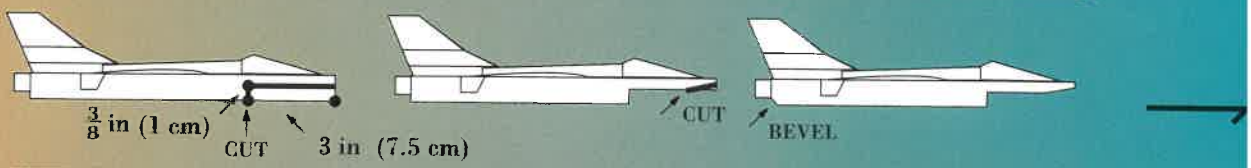






STEP 19 Apply glue and slide tail into fuselage. The tail sticks out of the back end of fuselage, with the vertical tail sliding into slit in the wings.

STEP 20 Use piece H to make the t
fuselage. Mountain fold in half horizont
On each side of crease, measure and v
shown. Make slit. Glue onto top of fus
shown. The vertical tail slides into slit.
snuggly over back of canopy.



STEP 21 Measure and cut nose, as shown. First cut a rectangular notch, then cut the ti
to give final shape to the nose. Bevel back of fuselage. This plane has no dihedral. Ventral fi
(slanted) 45°.

F18 Hornet

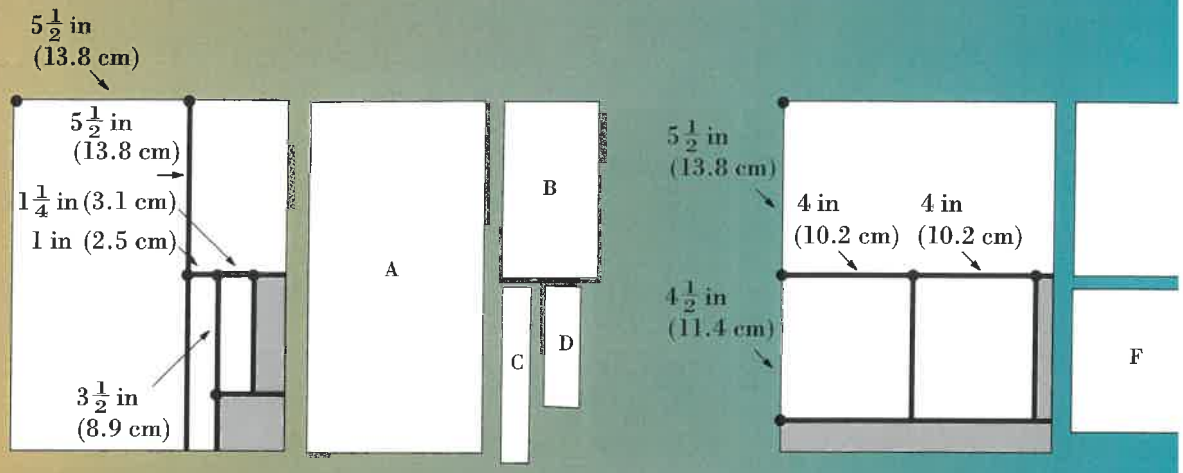
AL INFORMATION

used as a land-based fighter aircraft
s no equivalent sea-based fighter.
e F18 was built in the early 1980s as
zed multi-task maneuverable military
able of both sea and land operations.
commonly called the "Hornet." It has
gs and a conventional horizontal tail,
canted (tilted) vertical tails located
wings and horizontal tail. The F18 is
USA, Canada, Australia, and Spain.
irplane is modeled on the F18.

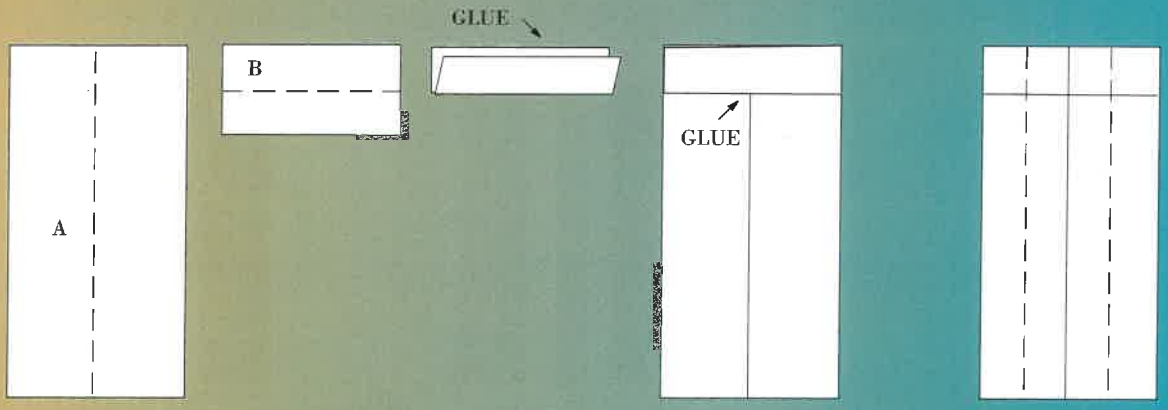
Technical Information

The F18 is constructed mostly of aluminum, with parts of its wings and other surfaces made of composites. It has two afterburning turbojet engines that can propel it at almost twice the speed of sound when traveling at high altitude. This airplane is both a fighter and an attack plane, and it can be fitted with a wide variety of armament for both air-to-air and air-to-ground military tasks. Like the F16, it has a missile rail at each wingtip, with space under the wings for other armament and extra fuel tanks. Besides its military role, this plane is also used as an aerial display airplane at air shows.

Making the F18



STEP 1 Measure and cut the various pieces from two sheets of bond paper.

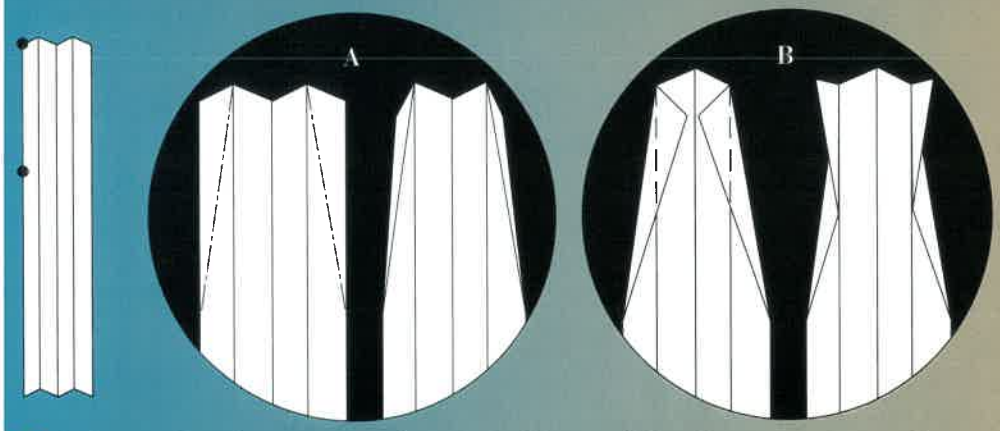


STEP 2 Use piece A to make the fuselage. Fold in half vertically using a valley fold. Unfold. Then valley fold piece B in half horizontally to make nose ballast. Glue halves together. Glue B to A, aligning top edges, as shown.

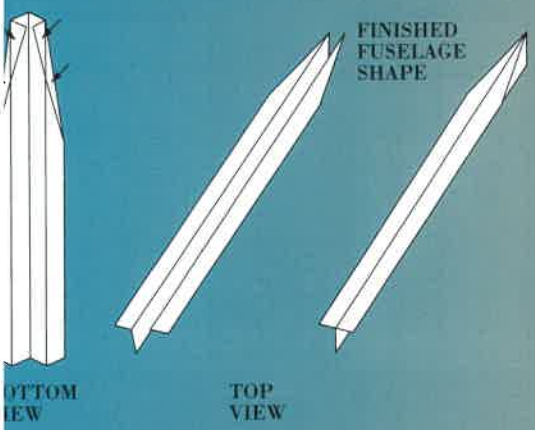
STEP 3 Valley fo
outer edges meet cen

STEP 4 Fold each side again using a mountain fold, so that outer edges meet center crease at back. Then adjust folds so that paper looks like an upside-down W, as shown.

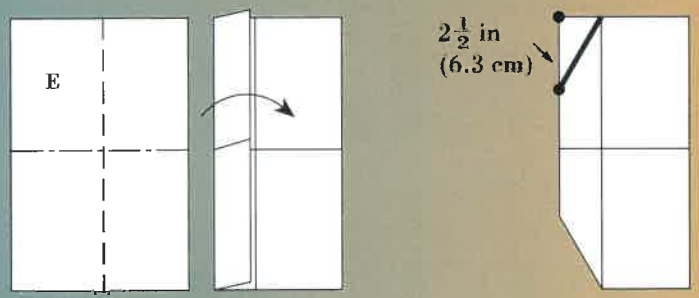
STEP 5 Unfold fuselage
Refold applying glue to con
surfaces, as shown. Make s
is straight.



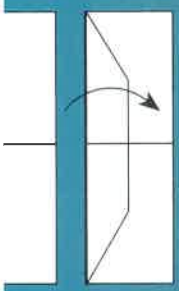
P 6 On each side, measure from top (front of fuselage), mark, and mountain long broken lines, as shown in enlarged view A. Then flip over fuselage. On each valley fold the triangle along the broken lines, matching fold line to existing crease, wn in enlarged view B.

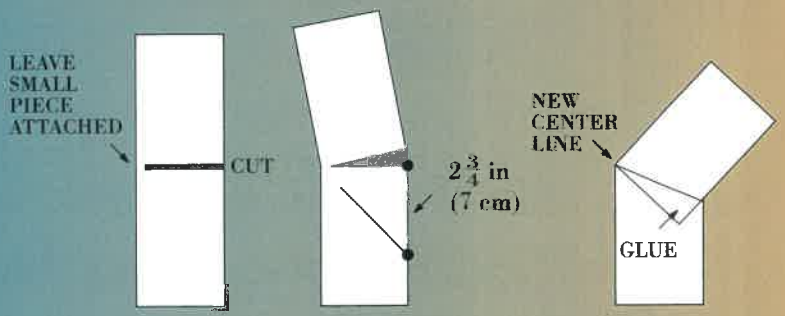


P 7 Glue triangles. Hold in place until ets. It is important that the fuselage stays ht. Do not glue nose yet.



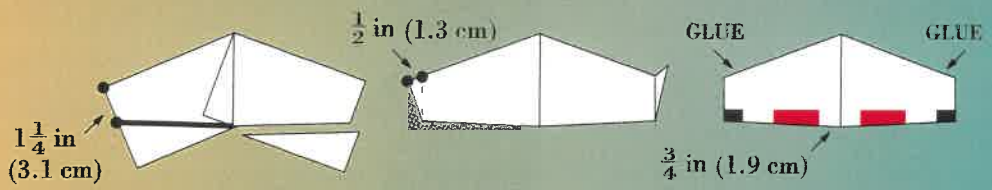
STEP 8 Lay piece E in a vertical direction to make wings. Valley fold in half vertically. Unfold. Mountain fold in half horizontally. Valley fold so that one outer edge meets center crease, as shown. On each side of horizontal center crease , measure and cut diagonally, as shown by heavy line.





P 9 Apply glue to each diagonal side on yer only, no more than 1 in (2.5 cm) from agonal edge. Refold along the original al center crease. The folded-over part is ttom of the leading edge (front) of wings.

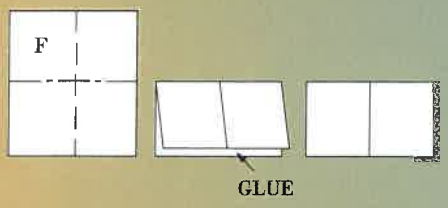
STEP 10 To taper wings, cut along center line from the trailing edge (back), leaving a small piece attached at the leading edge. Then measure and draw diagonal line, as shown. Align halves to the diagonal line. Glue. Draw new center line.



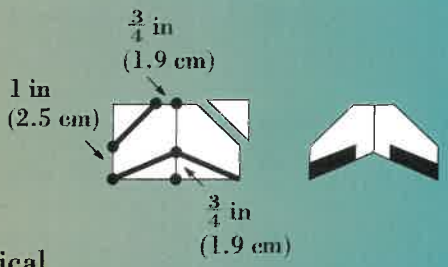
AILERONS
$\frac{1}{2}$ in x $\frac{1}{4}$ in
(1.3 cm x .6 cm)

FLA
$1\frac{1}{4}$
(3.

STEP 11 On each side, measure and cut trailing edge, as shown by heavy line. Then side, measure and mountain fold wingtips. Glue. Make ailerons and flaps in locations sho

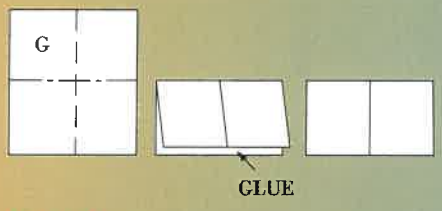


STEP 12 Lay piece F flat in a vertical direction to make the horizontal tail. Valley fold in half vertically. Unfold. Mountain fold in half horizontally. Glue halves together.

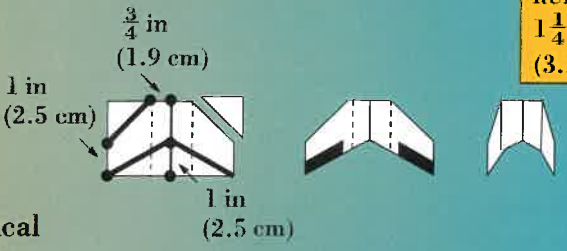


ELEVATORS
$1\frac{1}{4}$ in x $\frac{3}{8}$ in
(3.1 cm x 1 cm

STEP 13 On each side, measure and cut, as shown by heavy lines. Make elevators.



STEP 14 Lay piece G flat in a vertical direction to make the twin vertical tails. Valley fold in half vertically. Unfold. Mountain fold in half horizontally. Glue halves together.

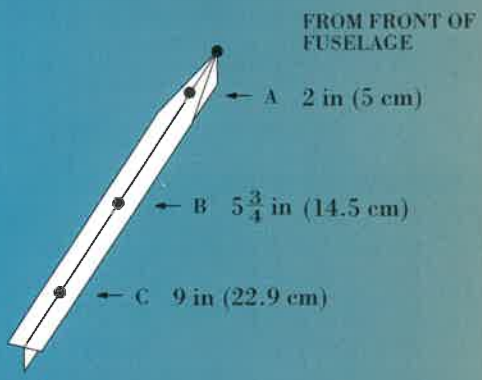


RUDDERS
$1\frac{1}{4}$ in x $\frac{1}{4}$ in
(3.1 cm x .6 cm

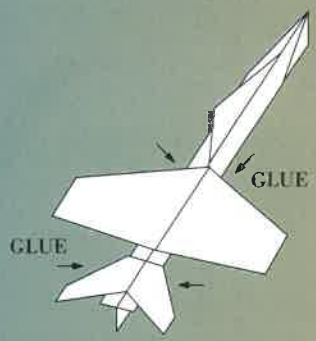
STEP 15 On each side, measure and cut, as shown by heavy lines. Make a rudder on each vertical tail. On each side, valley fold, as shown.

CANOPY (type 2)
$1\frac{1}{4}$ in x $3\frac{1}{2}$ in (3.1 cm x 8.9 cm)
Top point $2\frac{1}{2}$ in (6.4 cm)

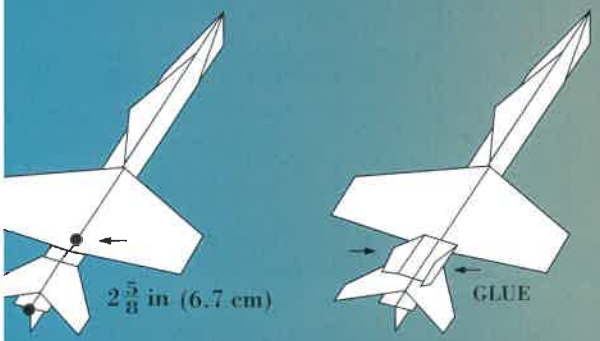
STEP 16 Use piece D to make the canopy (see p 28).

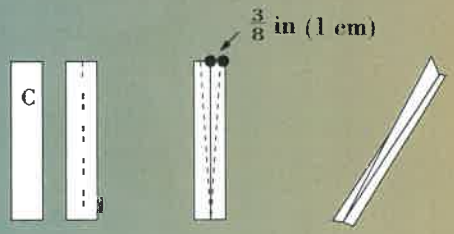


EP 17 Measure from front of fuselage, shown, and make mark A for positioning the nt of the canopy, mark B for positioning ding edge of the wings, and mark C for itioning leading edge of the horizontal tail.



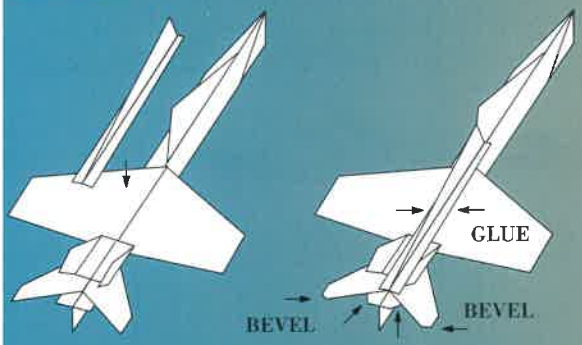
STEP 18 Apply glue to the inside of the nose and the small triangles on the bottom of the canopy. Position canopy on the fuselage at mark A. Hold until glue sets. Glue wings and horizontal tail in place, making sure they are centered and at right angles to the fuselage.

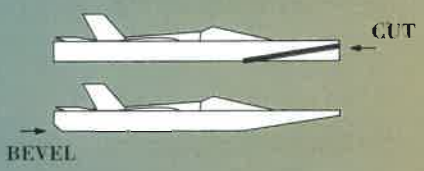




EP 19 Measure from back of fuselage, shown, and make a mark for positioning the n vertical tails. Glue vertical tails in place, king sure they are centered and parallel to fuselage.

STEP 20 Lay piece C in a vertical direction to make the fuselage top. Mountain fold in half vertically. Unfold. On each side, measure and valley fold. Adjust shape, as shown.





EP 21 Glue piece C onto the fuselage, king sure it fits snugly against the canopy. vel the trailing edges of the elevators.

STEP 22 Measure and cut nose diagonally, as shown by heavy line. Bevel all corners of the back of the fuselage. Wings and horizontal tail are level. Adjust angles of the canted (tilted) vertical tails, as shown.

747 Jumbo

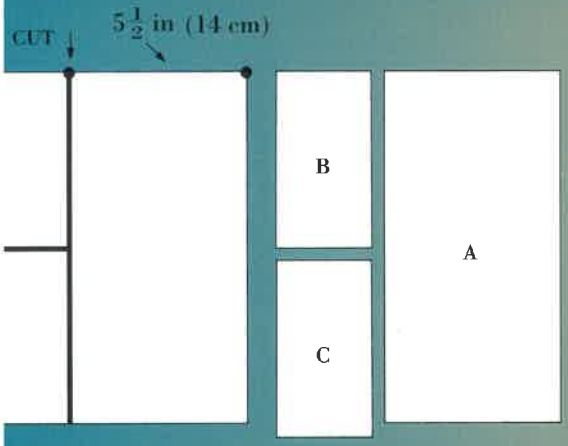
HISTORICAL INFORMATION

The first jet-powered airliner was the deHavilland Comet built in the 1950s. As more and more people realized the comfort of jet travel, bigger airplanes were needed to carry them. The Boeing 747 was first built in 1968. It is one of the largest passenger-carrying airplanes in the world. It is longer than the distance flown by the Wright brothers (120 ft or 36 m)) in their first powered flight. The "Jumbo Jet" is used to carry passengers and cargo across the continents and the oceans of the world. This paper airplane is modeled on the 747.

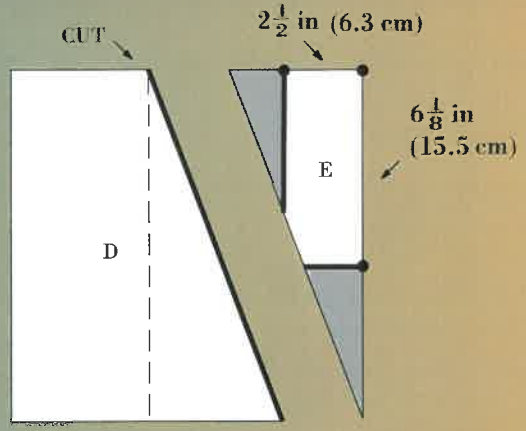
Technical Information

The Boeing 747 is a big airplane. From n
measures 230 ft (69 m). The distance fro
wingtip is 195 ft (58.5 m). Its tail is 64 ft
higher than a five storey building. When i
loaded with fuel, passengers, and cargo, i
800,000 lb (360,000 kg), and carries 50
or 270,000 lb (121,500 kg) of cargo. On
high altitude, it cruises at 600 mph (960
makes it ideal for use on long-distance pa
routes. Its service ceiling is 40,000 ft (12
above the ground. Its maximum range is
(9600 km), allowing it to fly one fourth of
around the earth without refueling. The pl
propelled by four 50,000 lb thrust turbo
engines.

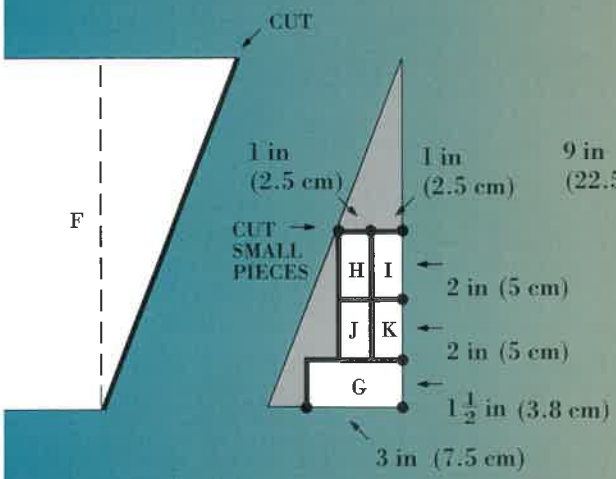
Making the 747



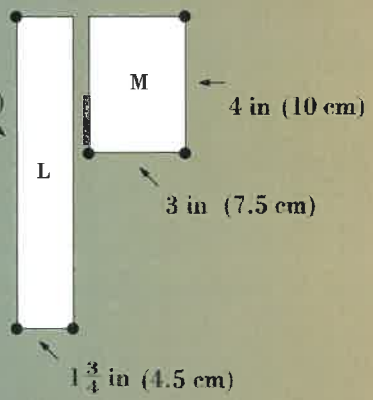
TEP 1 Measure and cut three pieces from heet of bond paper, as shown.



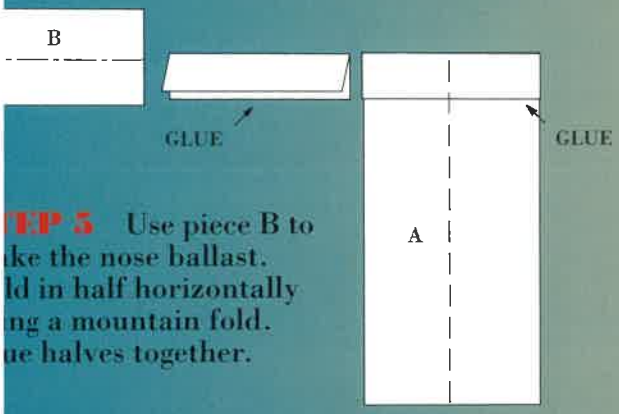
STEP 2 Valley fold a second sheet of bond paper in half vertically. Then measure and cut two pieces, as shown.



TEP 3 Valley fold a third sheet of bond paper half vertically. Then measure and cut six ces, as shown.

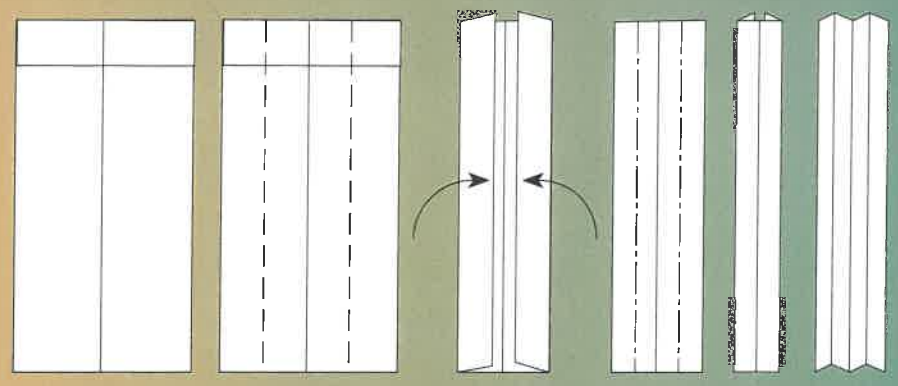


STEP 4 Measure and cut two additional pieces, as shown.



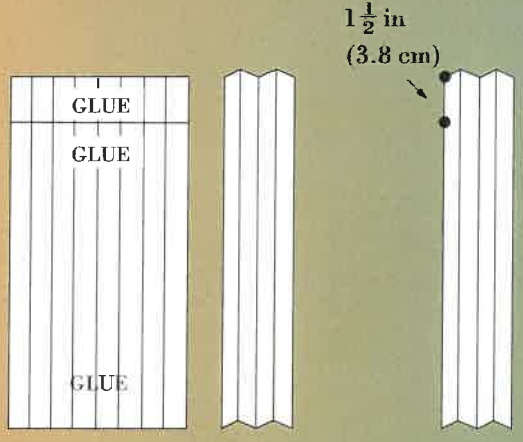
TEP 5 Use piece B to ke the nose ballast. ld in half horizontally ng a mountain fold. ue halves together.

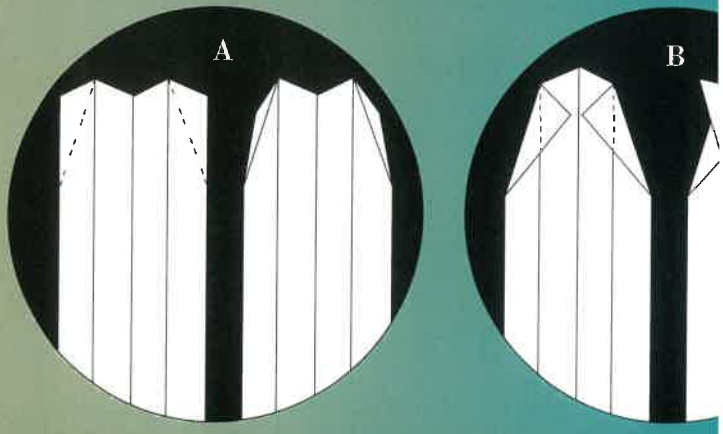
STEP 6 Use piece A to make the fuselage. Glue ballast to the top of fuselage, as shown. Fold in half vertically using a valley fold. Unfold.



STEP 7 Valley fold each side so that outer edges meet center crease, as shown.

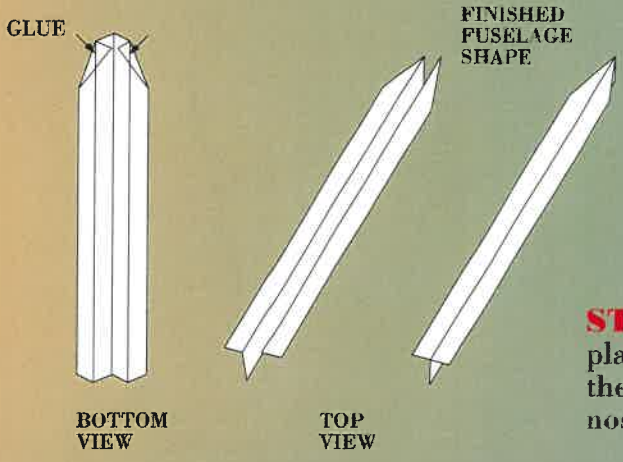
STEP 8 Fold each side again using a mounta that outer edges meet center crease at back. Th folds so that paper looks like an upside-down W



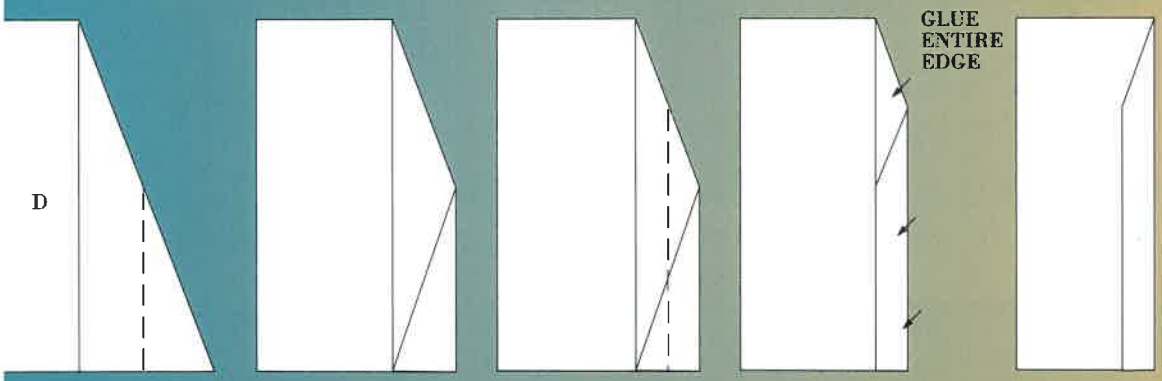


STEP 9 Unfold fuselage completely. Refold applying glue to contacting surfaces, as shown. Make sure fuselage is straight.

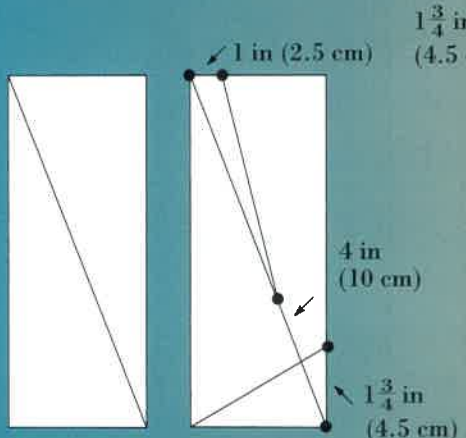
STEP 10 On each side, measure from top (fro fuselage), mark, and mountain fold along broken shown in enlarged view A. Then flip over fuselage. side, valley fold triangle along broken lines, matc line to existing crease, as shown in enlarged view B



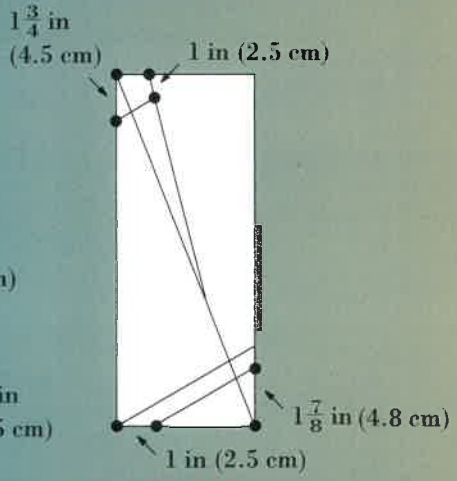
STEP 11 Glue triangles. Hold in place until glue sets. It is important that the fuselage stays straight. Do not glue nose yet.



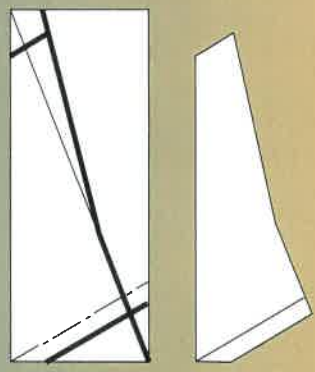
P 12 Lay piece D vertically to make the right wing. Valley fold vertically so that
om outer edge meets center crease. Valley fold vertically again so that outer edge meets
er crease. Apply glue. Then fold over again along original vertical center crease.



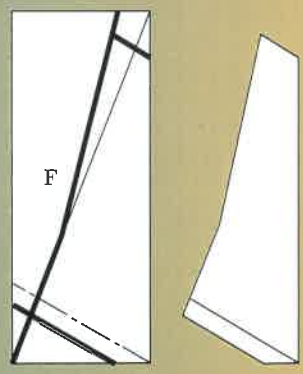
Flip over, with folded-over edge to
Draw diagonal line from upper left
ht corners. Measure along line from
make a mark. Measure along top
eft and mark. Join the two marks.
ure along right edge from bottom and
this point with the bottom left



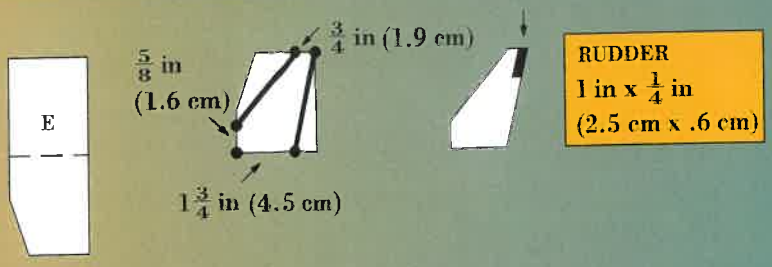
STEP 14 Measure along left edge from top and make a mark. Measure along line from top, as shown, and make a mark. Join the two marks. Then measure along bottom edge from left and make mark. Measure along right edge from bottom and make a mark. Join marks.



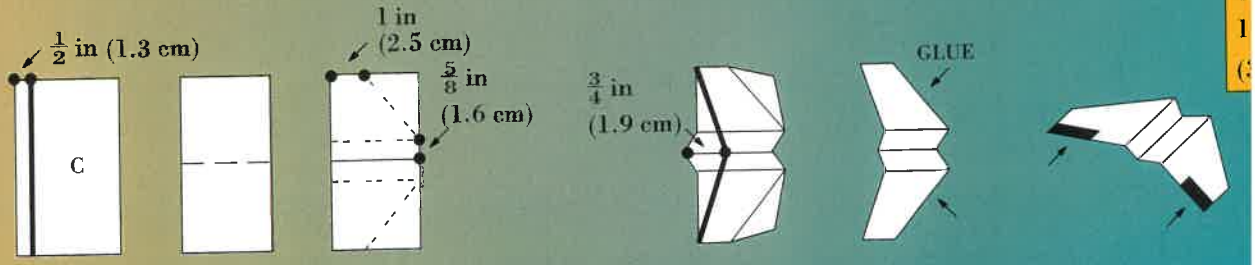
STEP 15 Cut along heavy lines, as shown. Then mountain fold along line, as shown.



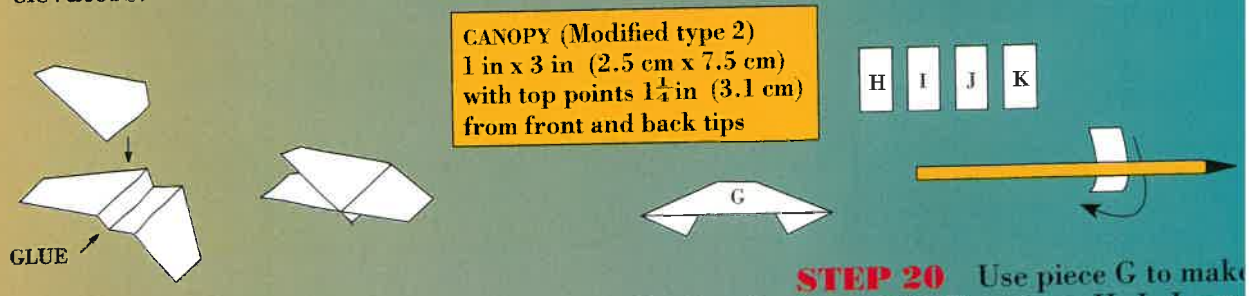
P 16 To make the left wing, repeat steps 12-15 using piece F,
ing the folded edge on the RIGHT and reversing the directions of
ines from left to right, as shown.



STEP 17 Lay piece E vertically to make the vertical tail. Valley fold in half horizontally and glue halves together. Then cut along heavy lines, as shown. Make rudder on trailing edge.

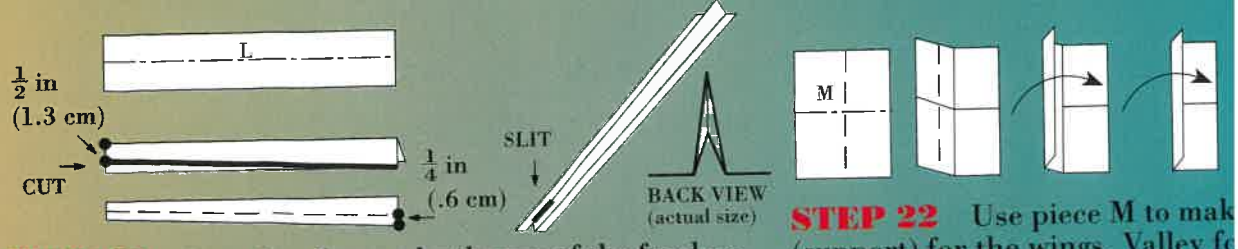


STEP 18 Lay piece C vertically to make the horizontal tail. Measure and cut to size. Va half horizontally. Unfold. On each side, measure from center crease, as shown, and mount each side, measure and mountain fold leading edge along broken lines. Glue. Cut trailing ed elevators.



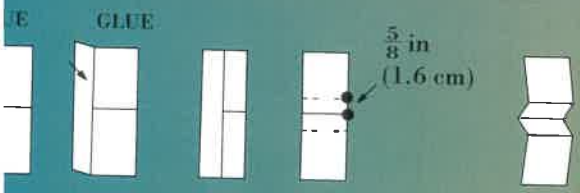
STEP 19 Apply glue to inside of horizontal tail and insert vertical tail, aligning leading (front) edges.

STEP 20 Use piece G to mak (see p 28). Use pieces H, I, J, an the engines. Wrap each piece aro vertically and glue.

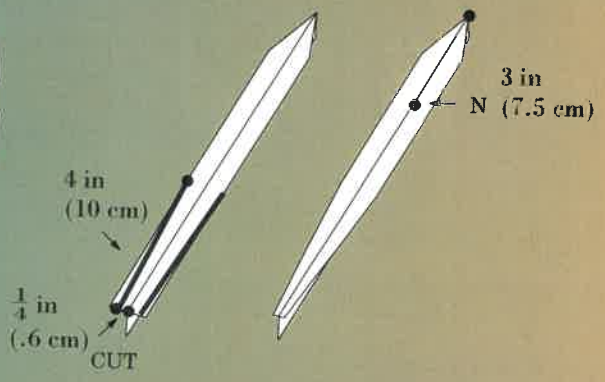


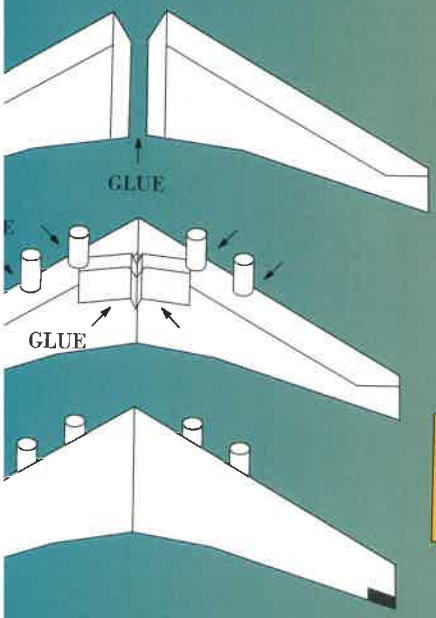
STEP 21 Use piece L to make the top of the fuselage. Mountain fold in half horizontally. Then, on each side, measure and valley fold to form piece, as shown. Cut a 1 in (2.5 cm) slit along center crease at narrow end.

STEP 22 Use piece M to mak (support) for the wings. Valley fo vertically. Unfold. Mountain fol horizontally. Unfold. Then valley so that outer edge meets center c over again along original vertical



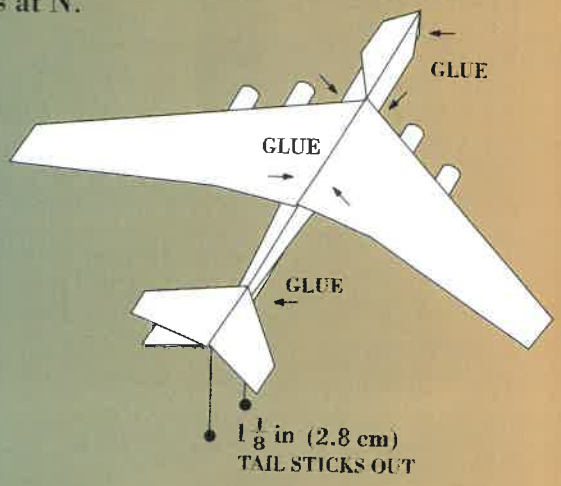
P 23 Unfold spar completely. Refold, ying glue to contacting surfaces. Flip over. ach side of center crease, measure and ntain fold, as shown. Folded over edge is ront.



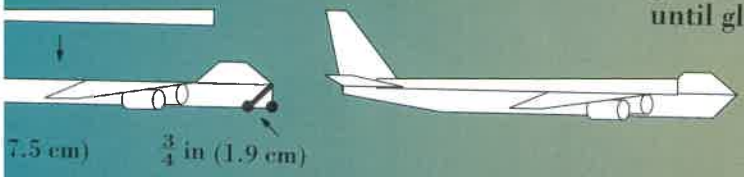


AILERONS
3/4 in x 1/4 in
(1.9 cm x .6 cm)

STEP 24 Measure back of fuselage and cut, as shown. Then measure from front and make mark for positioning leading edge of wings at N.



P 25 With wings upside down, glue s together. Glue spar to wings. Glue es to wings in approximate positions (they stick out 1/2 in (1.3 cm). Flip over. ailing edges, make ailerons.



STEP 26 Apply glue to inside of fuselage, the small triangles on the bottom of canopy, and the center bottom of wings. Slide canopy tabs into fuselage aligning with front tip. Immediately slide wings in place. Then apply glue and slide tail into back of fuselage. Hold until glue sets.

P 27 Measure and cut nose and tail ends diagonally heavy lines, as shown. Glue L onto top of fuselage, wn, fitting snuggly against back of canopy, with l tail through the slit. Adjust dihedral (upward g of wings and tail), as shown.

FSW Concept

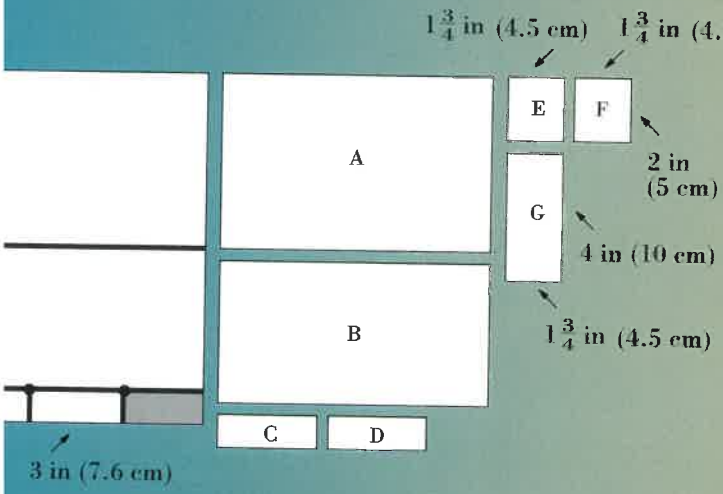
HISTORICAL INFORMATION

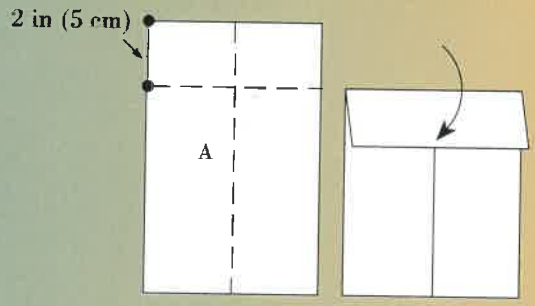
Airplane builders are always trying to make planes that are more suited to special tasks. In the 1980s a new shape of airplane appeared. Grumman introduced the X29 forward swept wing (FSW) experimental airplane, using new composite materials that were very light and strong. Such a design was impossible to build with traditional materials. The advantages of sweeping the wings forward instead of backward allow for maneuverability and high angle of attack flight — desirable qualities for military application. This paper airplane is modeled on a forward swept wing aircraft that has not yet been built. This concept, designed by Grumman, is being considered for possible future development.

Technical Information

A future fighter will have to operate o
of speeds, be very maneuverable, and h
It will have to be able to land in very s
Forward swept wings combined with st
of the leading edges near the fuselage)
flight characteristics of the plane at ve
high speeds. However, having no horiz
the plane sensitive to correct balance.
will aid in control. The light weight of
lack of a horizontal tail, and better en
improved fuel efficiency. The FSW Co
probably have two turbojet engines au
at more than twice the speed of sound
Its air intakes will be part of the large
plane will have a missile rail at each w
able to carry extra fuel tanks and a va
armament under the wings. Like pres
this craft will be used for both air-to-a
ground operations. Besides its militar
airplane could be a good candidate fo
at air shows.

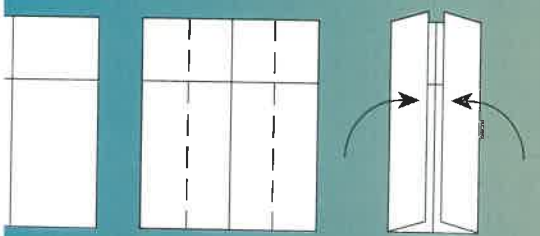
aking the FSW Concept

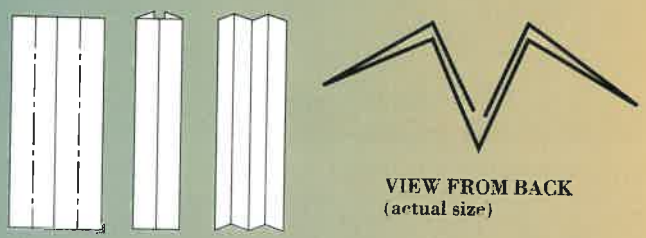




P 1 Measure and cut pieces from a sheet
id paper. Three additional pieces, E, F,
are needed, as shown.

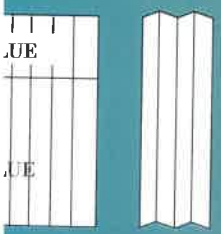
STEP 2 To make the fuselage, lay piece A in a vertical direction. Fold in half vertically, using a valley fold. Unfold. Measure from top and valley fold, as shown.



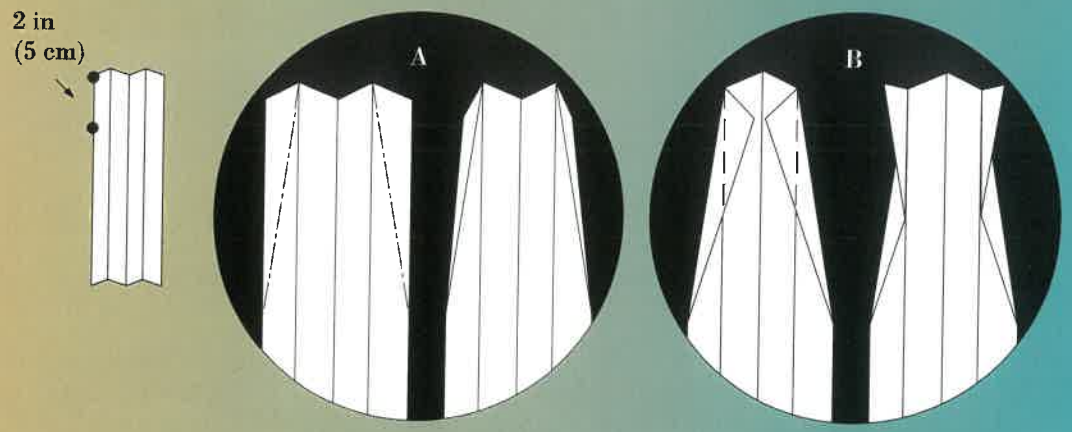


P 3 Valley fold each side so that
edges meet center crease, as shown.

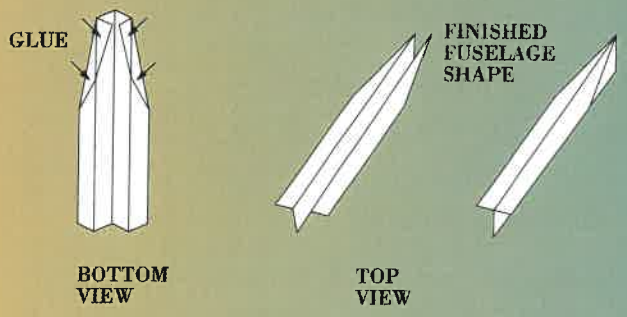
STEP 4 Fold each side again using a mountain fold, so that outer edges meet center crease at back. Then adjust folds so that paper looks like an upside-down W, as shown.



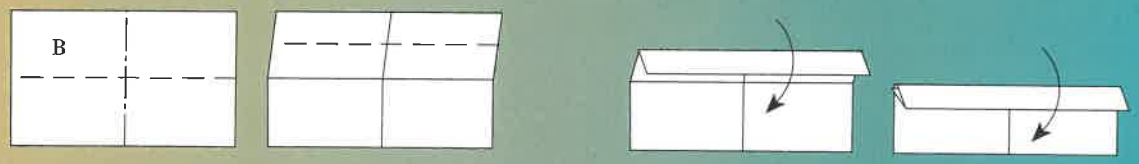
5 Unfold fuselage completely.
applying glue to all contacting
s, as shown. Make sure fuselage
ght.



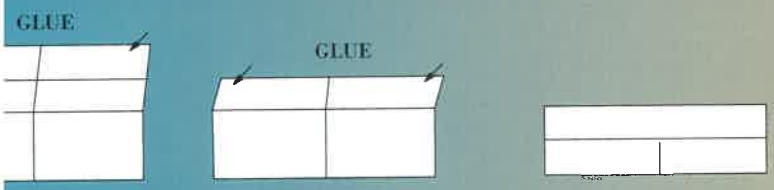
STEP 6 On each side, measure from top (front of fuselage), mark, and mountain f along broken lines, as shown in enlarged view A. Then flip over fuselage. On each side valley fold triangle along broken lines, matching fold line to existing crease, as shown i enlarged view B.



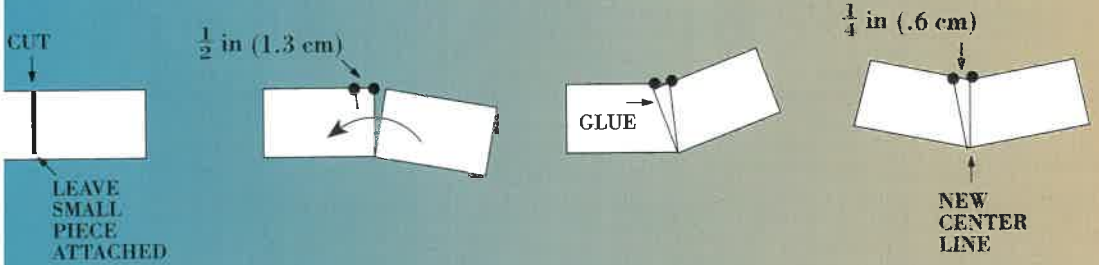
STEP 7 Glue triangles. Hold in place until glue sets. It is important that the fuselage stays straight. Do not glue nose yet.



STEP 8 Use piece B to make the wings. Lay paper in a horizontal direction and fold vertically, using a mountain fold. Unfold. Valley fold in half horizontally. Unfold. Then fold horizontally so that top edge meets center crease. Fold over again along original cent

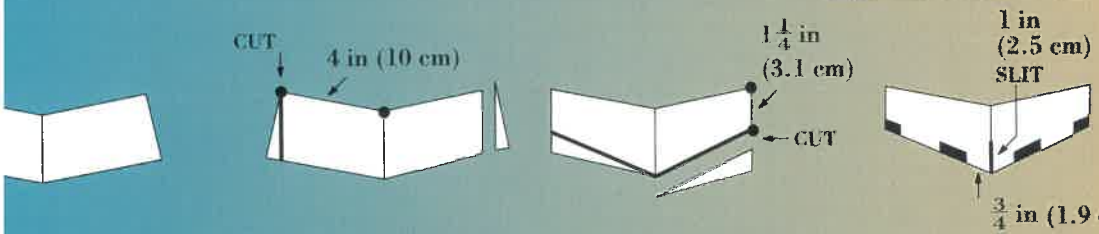


9 Unfold completely. Refold, applying glue to no more than 1 in (2.5 cm) from outer tips, wn. The folded over part is the bottom of the leading edge (front) of the wings.



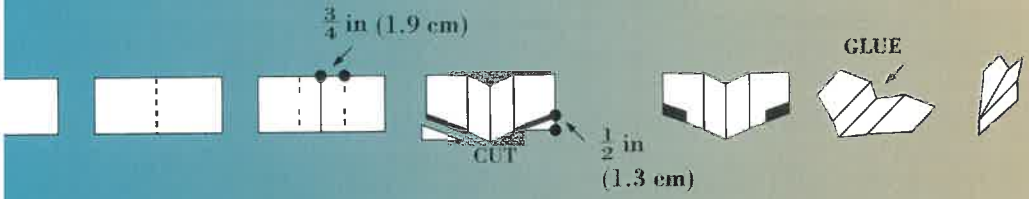
10 To sweep wings forward, cut along center line from the leading edge, leaving a small attached at the trailing edge (back). Then measure and make a mark on leading edge, as . Align pieces to the mark. Glue. Measure and draw new center line.

AILERONS	ELEVATORS
$\frac{1}{2}$ in x $\frac{1}{4}$ in (1.3 cm x .6 cm)	1 in x $\frac{3}{8}$ in (2.5 cm x 1 cm)



11 To finish forward swept wings, measure and cut wing tips along heavy lines. Then ailing edge along heavy lines, as shown. On trailing edges (back), make ailerons and elevators. trailing edge, make a slit along center line, as shown.

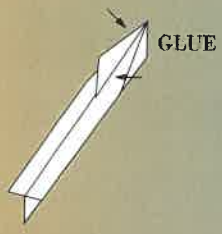
RUDDERS
1 in x $\frac{3}{8}$ in (2.5 cm x 1 cm)



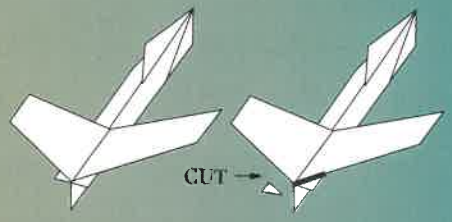
12 Use piece G to make the twin vertical tails. Lay paper in a horizontal direction. Valley n half vertically. Unfold. On each side, measure from center crease and mountain fold, as n. Then measure and cut trailing edges, as shown by heavy lines. Make rudders. Glue center.

CANOPY (type 2
$1\frac{1}{4}$ in x 3 in (3.1
Top point $1\frac{3}{4}$ in

STEP 13 Use piece C to make a type 2 canopy (see p 28).

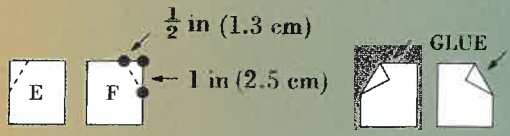


STEP 14 Apply glue to inside of nose and the small triangular tabs on the bottom of canopy. Slide tabs into fuselage, aligning canopy with the tip of the nose. Hold until glue sets.

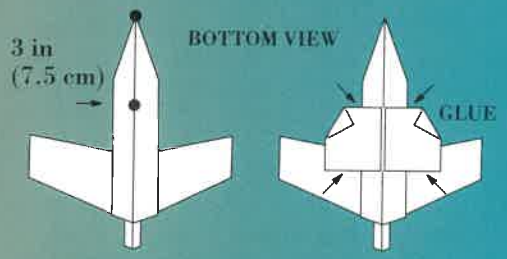


STEP 15 Glue wings in place, aligning at the trailing (back) edge. Make sure they are centered and at right angles to the fuselage. Trim fuselage back flush with the wing trailing (back) edges.

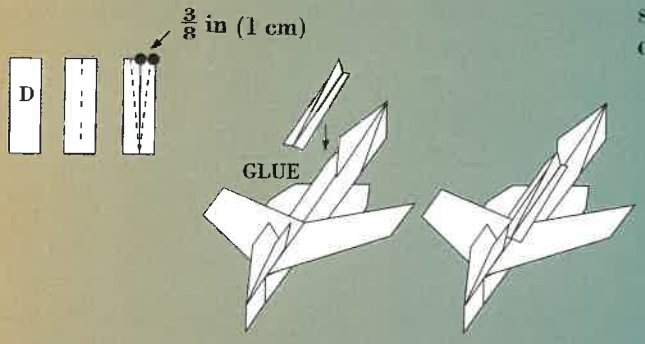
STEP 16 Me
mark along bott
Apply glue and s
back of fuselage
the wings) to the



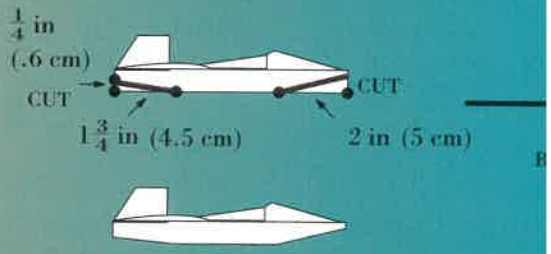
STEP 17 Use pieces E and F to make the strakes. Lay pieces vertically side by side, as shown. Measure on outer left and right edges and valley fold diagonally, as shown. Glue.



STEP 18 Turn airplane over. Measu
from front and mark, as shown. On each
side, glue strakes in place, aligning inside
corners to the mark.

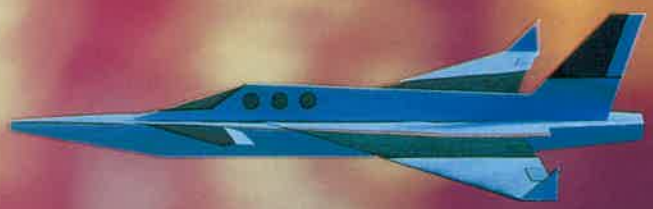


STEP 19 Lay piece D in a vertical direction to make the fuselage top. Mountain fold in half vertically. Unfold. On each side, measure and valley fold. Adjust shape, as shown. Glue onto top of fuselage, as shown, fitting the front snuggly over back of canopy.



STEP 20 Measure and cut nose an
diagonally, as shown by heavy lines. Th
has no dihedral. Twin tails are canted
as shown.

SST Concept



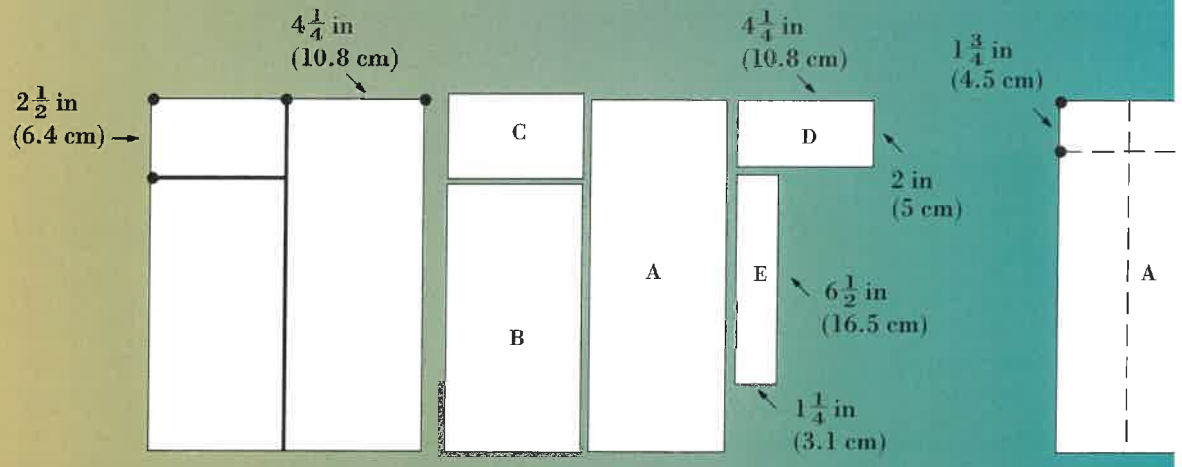
AL INFORMATION

r than the speed of sound can only be
s of the world where no people live,
loud sonic boom would break the
people's houses. Therefore, supersonic
ndertaken only between cities across
oceans. However, the Sukoi and
airplane companies are experimenting
of different shapes and sizes to see if
luce the intensity of the sonic boom. If
n be made quieter, supersonic air
een cities on the same continent or
same country would be possible. This
ane is modeled on a plane that has not
lt. It is a concept of a future supersonic
lane (SST).

Technical Information

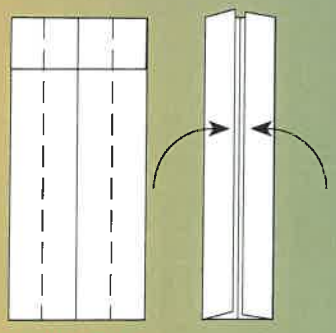
The type of airplane being planned is probably small, carrying no more than ten passengers. This small size would be one way of making the boom produced in supersonic flight less damaging. The goal is to make the plane capable of traveling nearly twice the speed of sound. It will probably be built of lightweight composite materials and use computers for flight control. The plane's main wings will be delta wings with winglets at the tips. Winglets help direct the airflow over the wings. Canard wings for added control will also be used. This plane might be the business jet of the future.

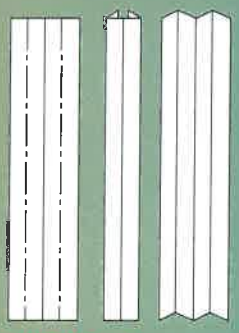
Making the SST



STEP 1 Measure and cut the various pieces from a sheet of bond paper. Two additional pieces, D and E, are needed, as shown.

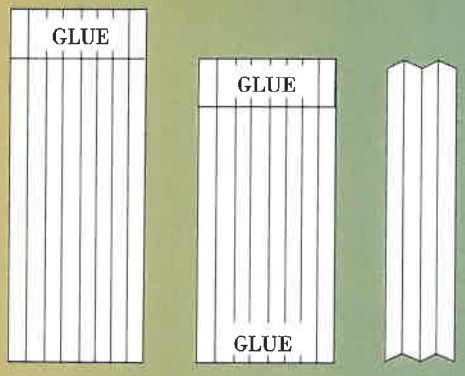
STEP 2 To n
fuselage, fold pi
vertically using
Unfold. Measur
valley fold, as s



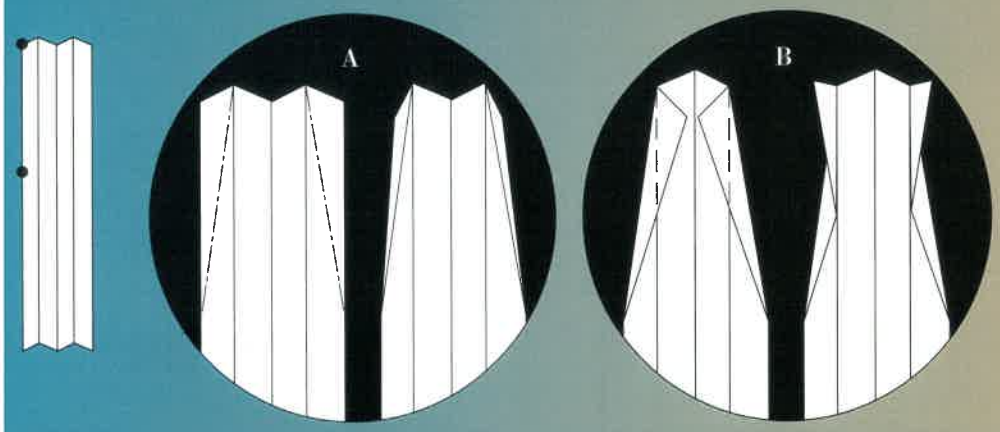


STEP 3 Valley fold each side so that outer edges meet center crease, as shown.

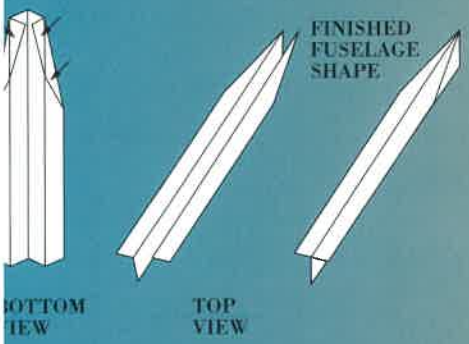
STEP 4 Fold each side again using a mountain fol
outer edges meet center crease at back. Then adjust
that paper looks like an upside-down W, as shown.



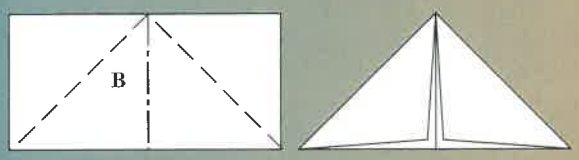
STEP 5 Unfold fuselage completely. Refold applying glue to contacting surfaces, as shown. Make sure fuselage is straight.



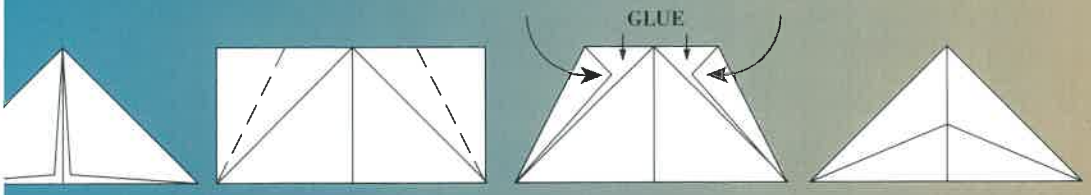
P 6 On each side, measure from top (front of fuselage), mark, and mountain fold broken lines, as shown in enlarged view A. Then flip over fuselage. On each side, fold triangle along broken lines, matching fold line to existing crease, as shown in ed view B.



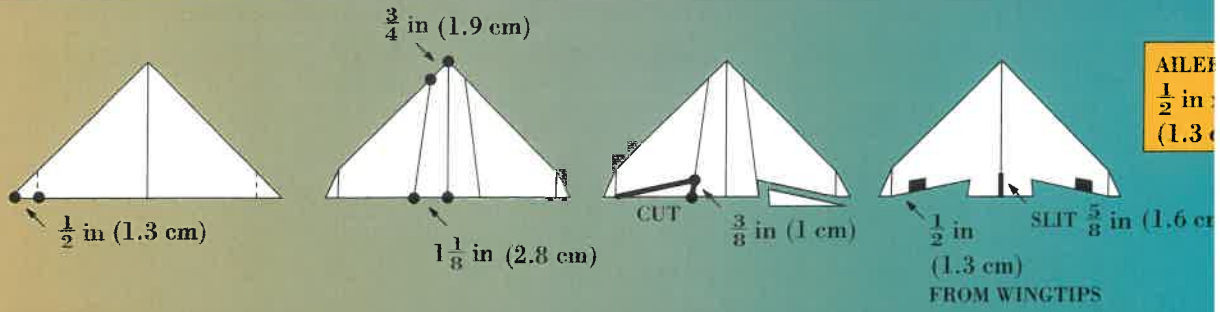
P 7 Glue triangles. Hold in until glue sets. It is important the fuselage stays straight. Do not nose yet.



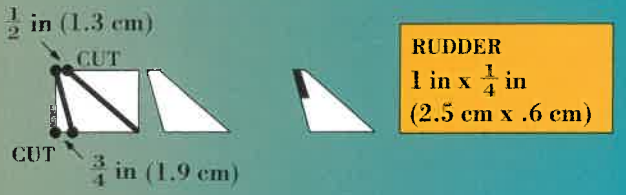
STEP 8 Lay piece B flat in a horizontal direction to make the wings. Fold in half vertically, using a mountain fold. Unfold. On each side, valley fold diagonally so that top edge meets center crease, as shown.



P 9 Unfold diagonal folds. On each side, valley fold diagonally so that outer meet diagonal crease, as shown. Apply glue to small upper triangles only and original diagonal creases.

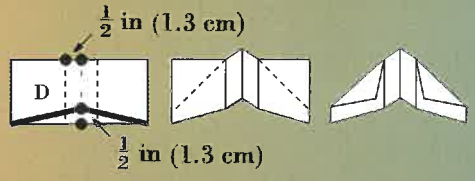


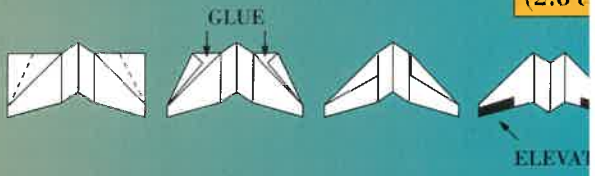
STEP 10 Flip wings over. To make winglets, measure at each wingtip and valley fold, as shown. Then on each side, measure and draw lines, as shown. At the trailing edge, measure and cut, as shown by heavy lines. Make ailerons in locations shown. Measure and cut a slit in location shown.



STEP 11 Lay piece C in a vertical direction. Mountain fold in half horizontally to make the vertical tail. Glue halves together.

STEP 12 Measure and draw lines, as shown. Cut diagonally, as shown by heavy lines. Make the rudder, as shown.



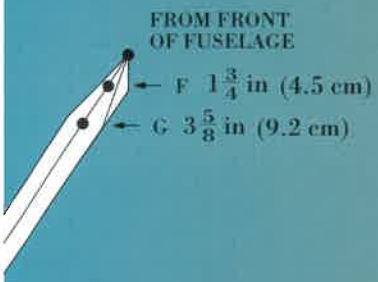


STEP 13 Lay piece D in a horizontal direction to make canard wings. Mountain fold in half vertically. Unfold. Measure from bottom along center crease and cut, as shown by heavy lines. On each side, measure and valley fold. Then on each side, fold diagonally so that top edge meets vertical crease.

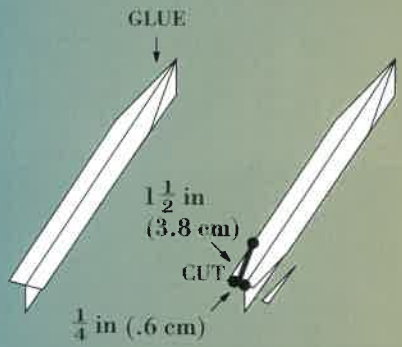
STEP 14 Unfold diagonal folds. On e side, valley fold diagonally so that outer meet diagonal creases, as shown. Apply g small upper triangles only and refold ori diagonal creases. Flip wings over and ma elevators in locations shown.

CANOPY (type 1)
$1\frac{1}{4}$ in x $6\frac{1}{2}$ in (3.1 cm x 16.5 cm)
Top point $1\frac{3}{4}$ in (4.5 cm)
Back $\frac{3}{8}$ in (1 cm)

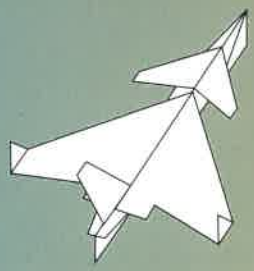
STEP 15 Use piece E to make a type 1 canopy (see p 28).



EP 16 Measure from front of elage and make marks for positioning leading edges of canard wings and opy at F and main wings at G, as wn.

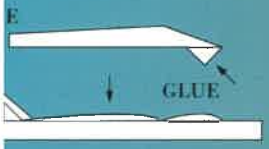


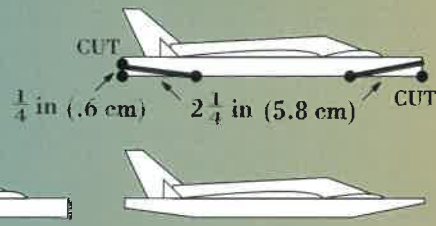
STEP 17 Apply glue to inside of nose, no more than 1 in (2.5 cm) from tip. Hold until glue sets. Then measure and cut back of fuselage, as shown. Glue canard wings in place. (Do not glue the inside center of the canard wings.)



EP 18 Glue main wings in place, king sure they are centered and at nt angles to the fuselage. Then measure m back of fuselage and mark.

STEP 19 Apply glue and slide vertical tail into back of fuselage so that trailing edge aligns with mark.

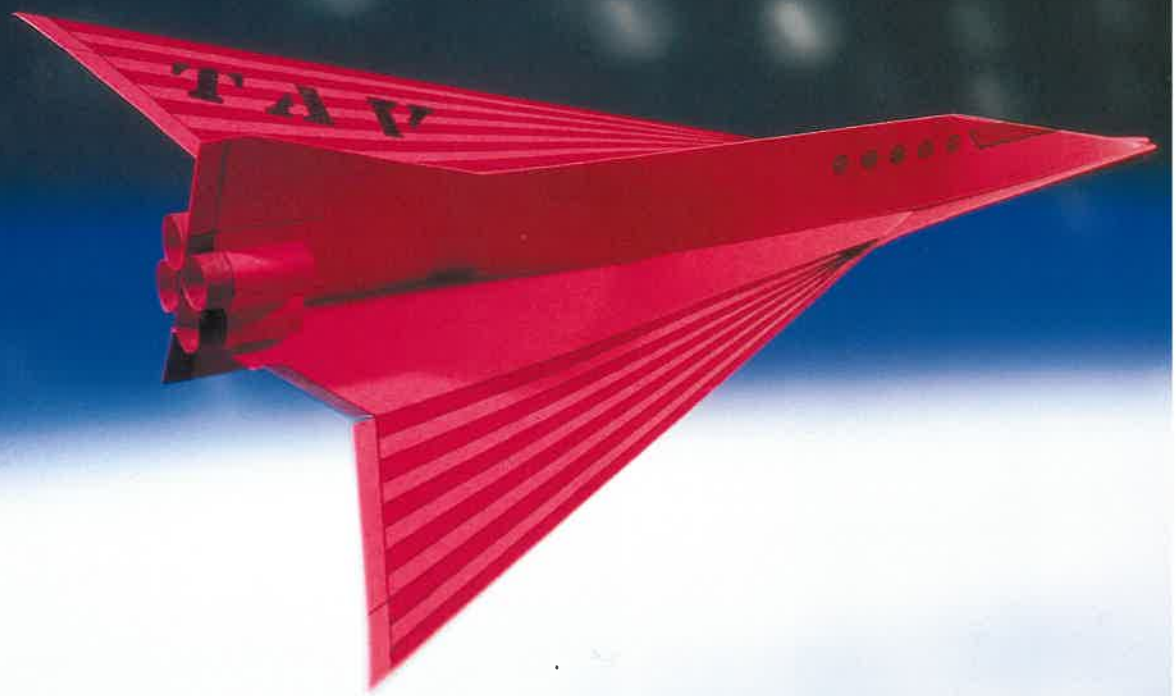




EP 20 Apply glue to the tabs on the tom of canopy and the inside back of the opy. Slide tab into center of canard gs with the slit fitting around the vertical . Align canopy front with front of canard gs.

STEP 21 Measure and cut nose and tail, as shown by heavy lines. The wings of this airplane have no dihedral. Adjust winglets to a vertical position.

TAV Concept



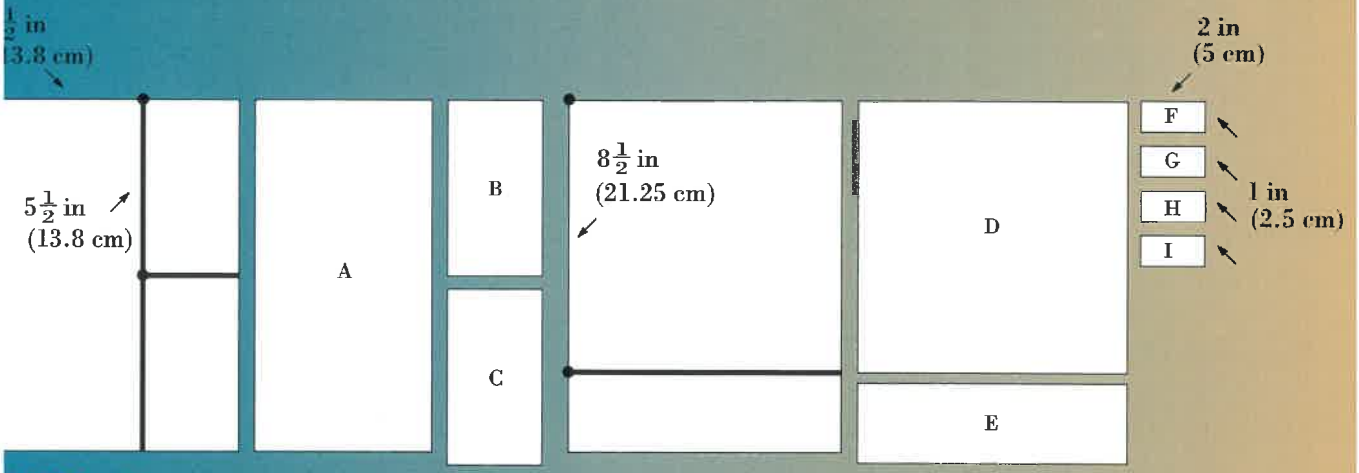
HISTORICAL INFORMATION

We are living on the threshold of a new era in air travel. Already the space shuttle is blasting into space attached to a rocket and returning as an airplane for another mission. The next generation of space planes will take off under their own power from ordinary airport runways, fly into space, and return back to earth. They are called trans-atmospheric vehicles (TAV). Sometimes they are called hypersonic transports (HST). They will combine jet and rocket engines for propulsion and have stable delta wings (triangle shaped) integrated into the fuselage for lift in the lower atmosphere. They will look something like the ordinary "paper plane." One example is NASAs experimental X30. This paper airplane is modeled on such future space planes.

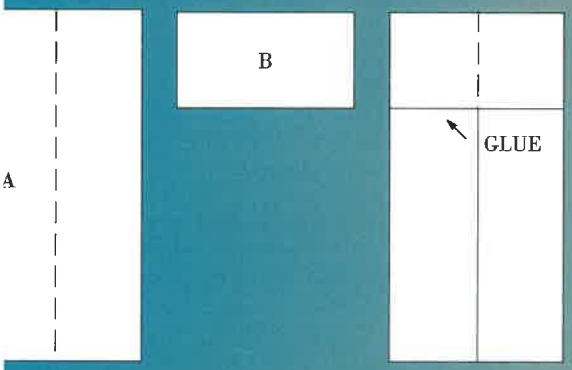
Technical Information

Trans-atmospheric vehicles will need pow
complicated engines and fuel supplies if t
from the ground up into space. It takes a
energy to propel an airplane beyond the
earth's atmosphere and go into space orl
the speed of sound. For example, the spa
have now uses over 1,000,000 lb (600,00
oxygen and 300,000 lb (120,000 kg) of
hydrogen, which it burns in under ten mi
The fuel is carried in large external tanks
thrown away during each flight. Future T
everything on-board, like a regular airplar
to engines for very high altitude, they wil
engines that can burn fuel using oxygen f
atmosphere at lower altitudes. Only at ve
altitudes, where there is not enough oxyg
to use, will they switch to an on-board sup
Space planes of the future will use less fu
much less oxygen. Such planes will be ab
competely around the world in just a few

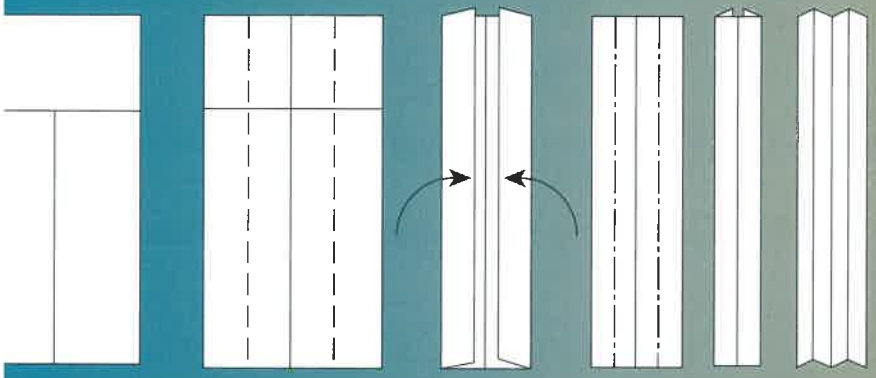
Making the TAV



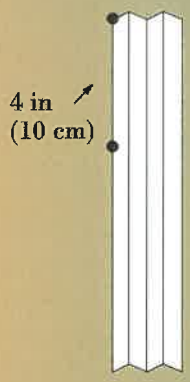
TEP 1 Measure and cut the various pieces from two sheets of bond paper. Four additional all pieces are needed, as shown.

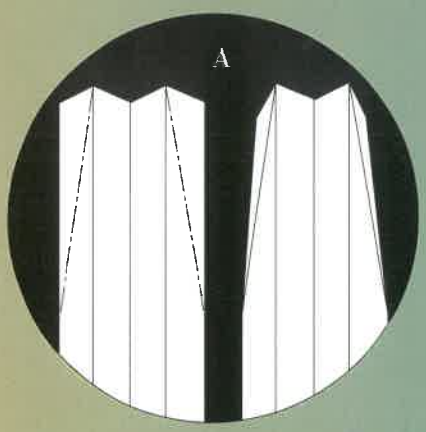


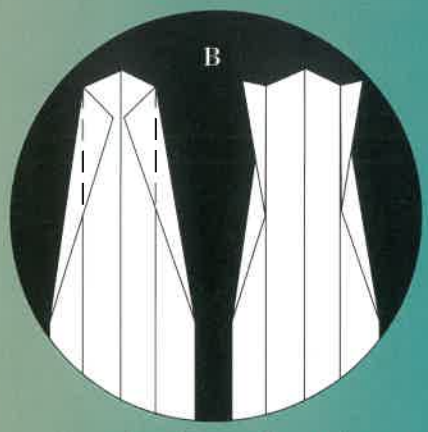
TEP 2 Lay piece A flat in a vertical direction. To make the fuselage, fold in half vertically ng a valley fold. Unfold. To make nose ballast glue piece B in place, aligning the top edges, as own. Refold center crease. Unfold again.



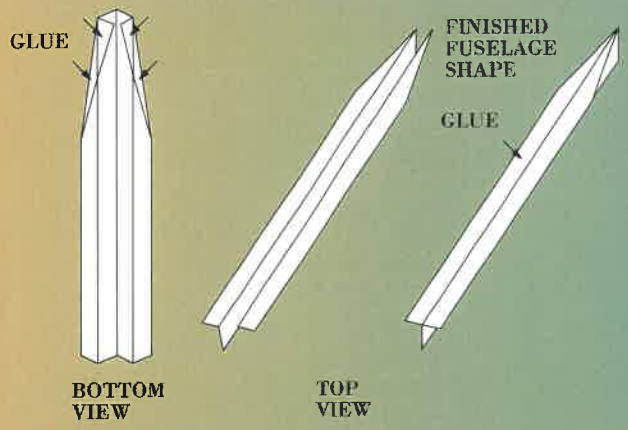
TEP 3 Refold in half vertically using a valley fold. Unfold. Valley fold each side so t outer edges meet center crease, as shown. Fold each side again using a mountain d, so that outer edges meet center crease at back. Then adjust folds so that paper ks like an upside-down W, as shown.

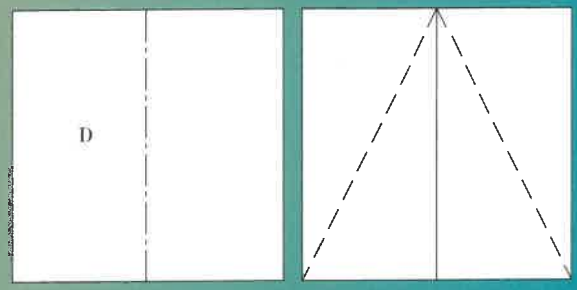






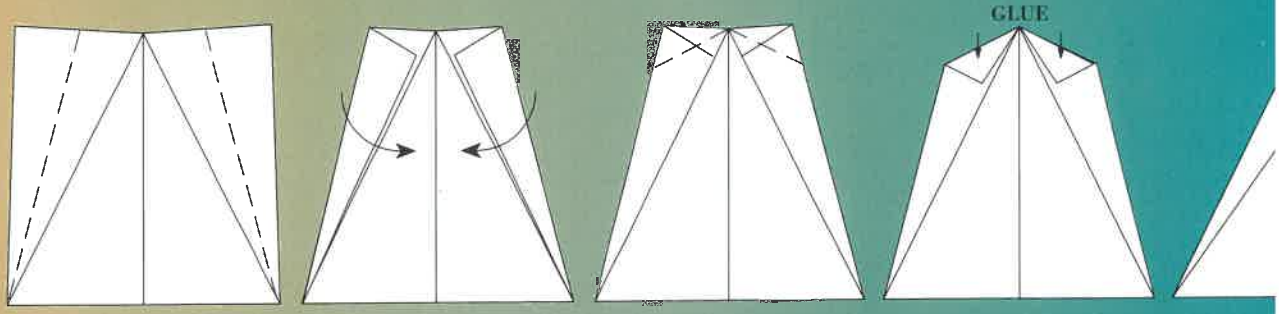
STEP 4 On each side, measure from top (front of fuselage), mark, and mountain fold along broken lines, as shown in enlarged view A. Then flip over fuselage. On each side, valley fold the triangle along the broken lines, matching fold line to existing crease, as shown in enlarged view B.



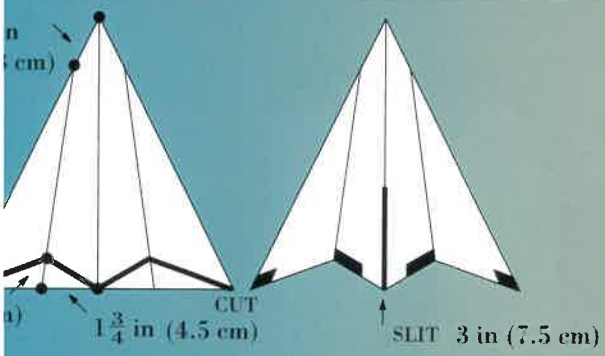


STEP 5 Glue triangles. Hold in place until glue sets. It is important that the fuselage stays straight. Glue fuselage in the middle only, leaving the nose and tail ends unglued.

STEP 6 Use piece D to make the wings. Mountain fold in half vertically. Unfold. T each side valley fold diagonally along a lin running from the top center to the bottom c Unfold.

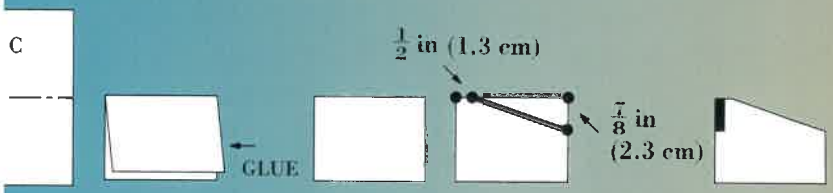


STEP 7 On each side, valley fold diagonally so that outer edges meet diagonal crease, as s Then fold so that upper edges meet diagonal crease, as shown. Apply glue to the small upper t only and refold original diagonal creases.



AILERONS	ELEVATORS
$\frac{3}{4}$ in x $\frac{1}{4}$ in (1.9 cm x .6 cm)	1 in x $\frac{1}{4}$ in (2.5 cm x .6 cm)

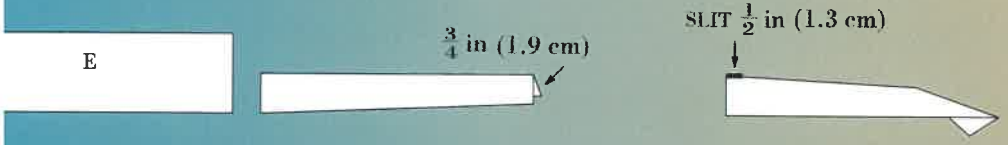
EP 8 Lay wings flat right side up. On each side measure from front tip and back center and w lines, as shown. Then cut wings, as shown by heavy lines. Make elevators and ailerons in ations shown. At the trailing (back) edge, cut a slit along center crease, as shown.



RUDDER
1 in x $\frac{1}{4}$ in (2.5 cm x .6 cm)

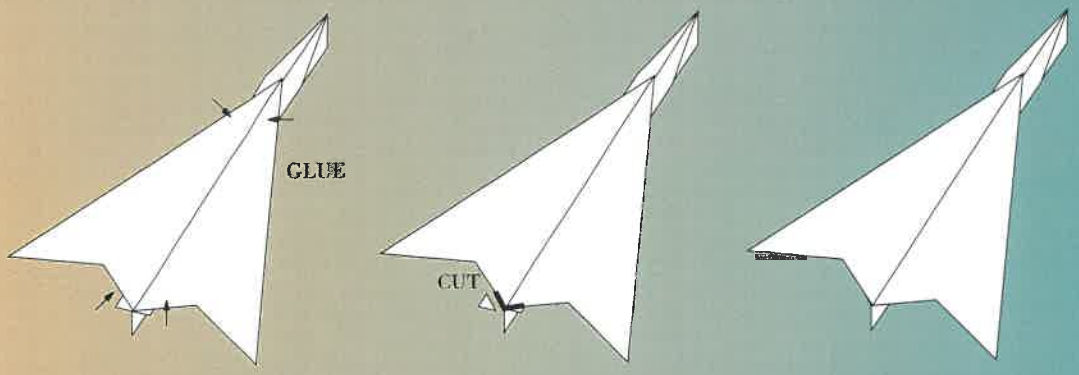
EP 9 Mountain fold piece C in half horizontally to make the vertical tail. Glue halves ether. Measure and cut, as shown by heavy line. Make rudder, as shown.

CANOPY (type 1)
3 in x 8 $\frac{1}{2}$ in (7.8 cm x 21.25 cm)
Top point 3 in (7.8 cm)
Front $\frac{3}{4}$ in (1.9 cm)

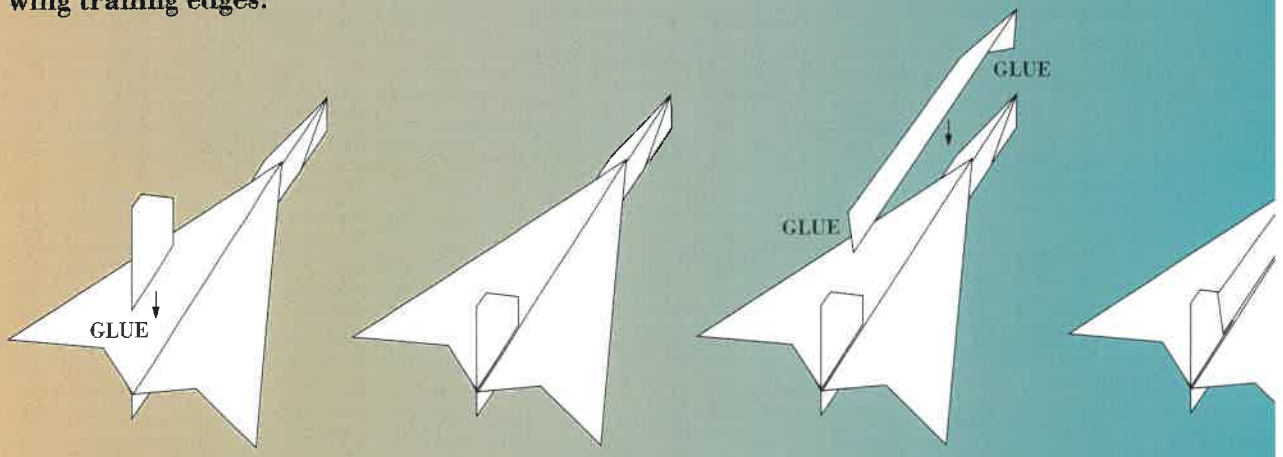


EP 10 Use piece E to make the type 1 canopy (see p 28). Note that this canopy is lower he front than at the back. Cut paper to size first.

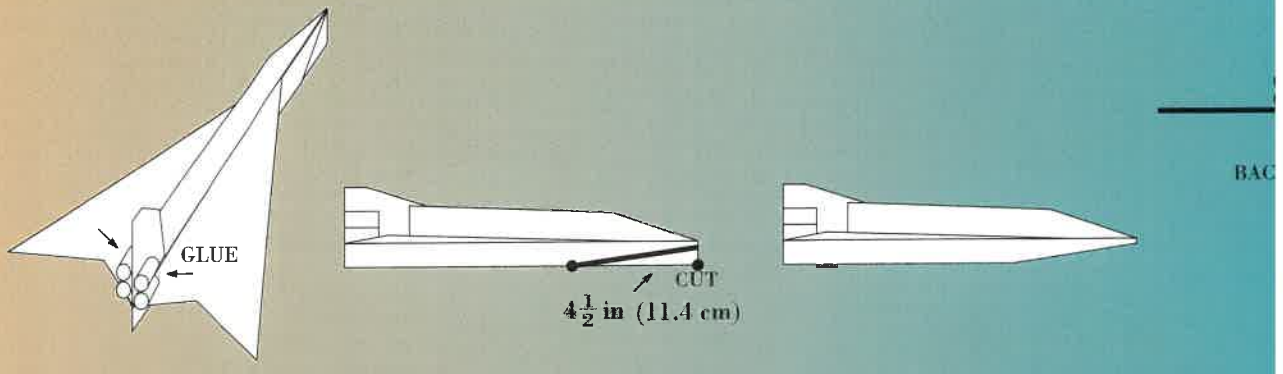
EP 11 Use pieces F, G, H, and I to make engines. Wrap paper around a felt pen tically and glue.



STEP 12 Glue wings to the fuselage, aligning trailing (back) edges. Make sure wings are centered and at right angles to the fuselage. Then trim back of fuselage to match wing trailing edges.



STEP 13 Apply glue and slide vertical tail into fuselage (and the slit in the wings). Align at (back) edges. Apply glue to the lower front tab of the canopy and the inside back. Position ca inserting tab into nose end of the fuselage and slipping the back over the vertical tail.



STEP 14 Attach the engines by gluing them to the vertical tail, two on each side, one on top the other, as shown. Align to the trailing edge of the vertical tail.

STEP 15 Measure and cut nose diagon shown by heavy line. This plane has no dih

ecoration

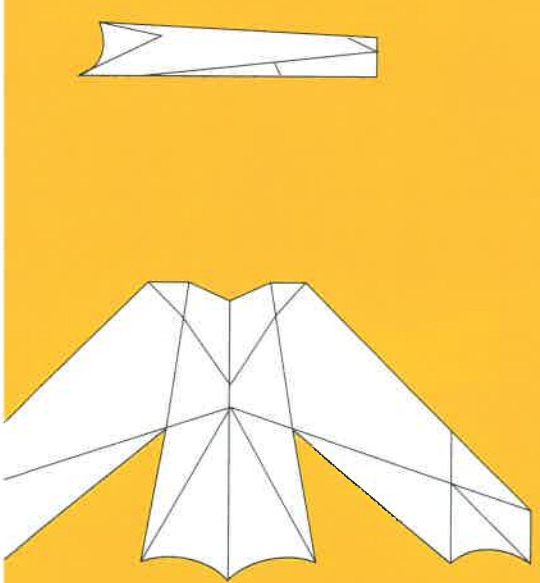
e following pages contain a plan (top) view
l an elevation (side) view of each of the
ber airplanes contained in this book. They
ve window outlines, outlines of control
faces, and other lines that help define each
ne's shape, all of which add to an airplane's
lism. Decorative patterns add interest.

e patterns can be copied, modified, or you
invent your own. A pattern such as a
ckerboard or a camouflage that is shown on
plane can easily be applied to another
plane design. Use your imagination. What
see here are suggestions. Or you can build
ber airplanes and leave them undecorated.
may wish to build undecorated trial planes
t so you can master their construction and
ht before you spend a lot of time on
oration.

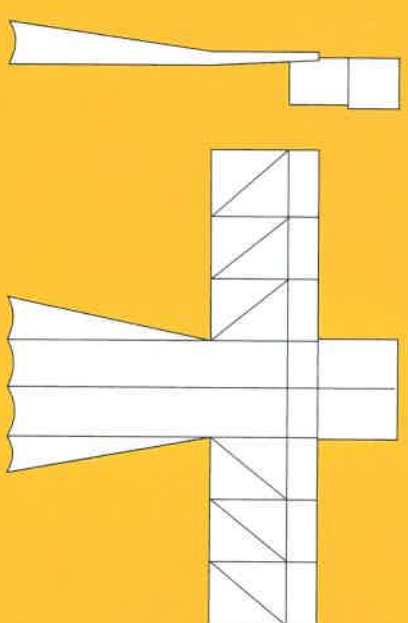
It is easier to add decoration to the airplanes before they are completely assembled. Some advanced planning is needed. Once you have decided on the pattern or design you want for the plane, decorate the pieces as you cut and fold them. Try each piece for fit and mark it carefully as you go along. Armament can be added to military planes using toothpicks. Draw the decoration lines using a very fine black felt-tipped pen. Narrow colored markers are ideal for filling in. Avoid water-based markers because they wrinkle the paper too much. Stencils can be used to add numbers and letters.

See the photographed airplanes for ideas on color schemes. Some of the patterns may be different from those shown here.

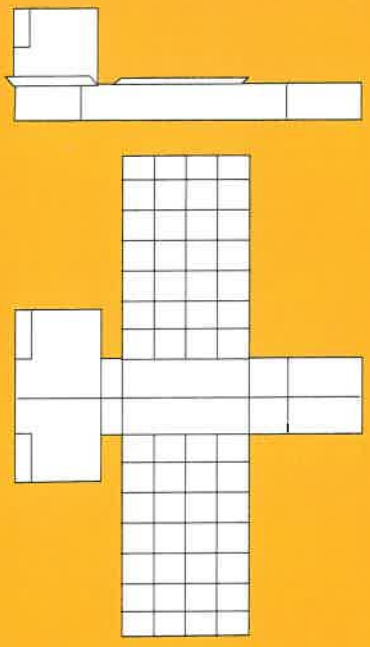
Bat
p 8 for color suggestions).



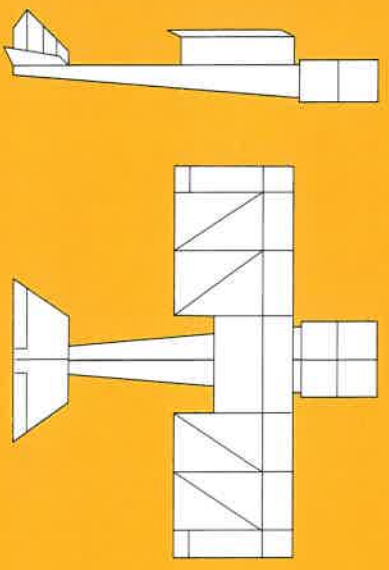
2 Sky Bird
(see p 10 for color suggestions).



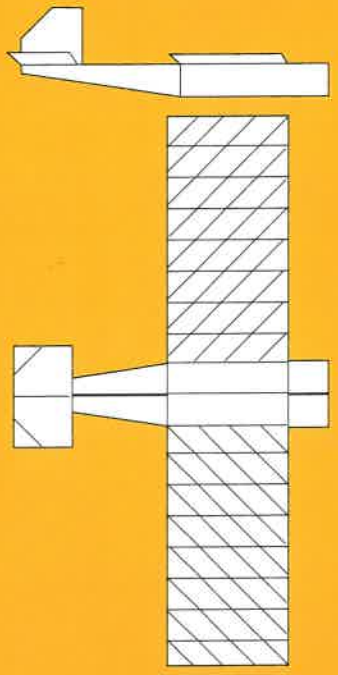
3 Plain Plane
(see p 13 for color suggestions).



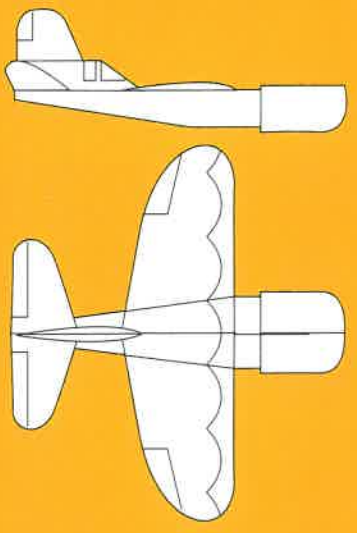
4 Biplane
(see p 16 for color suggestions).



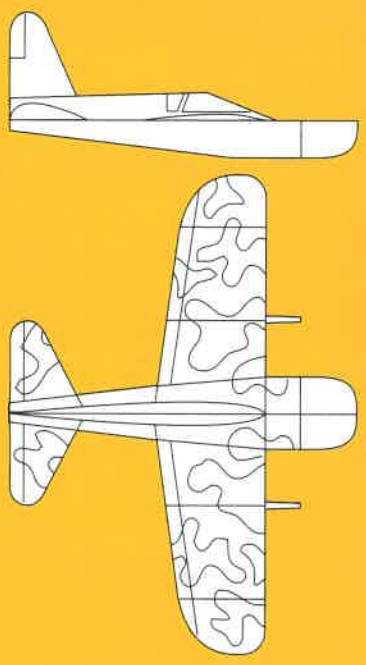
5 Aero Stunt
(see p 21 for color suggestions).



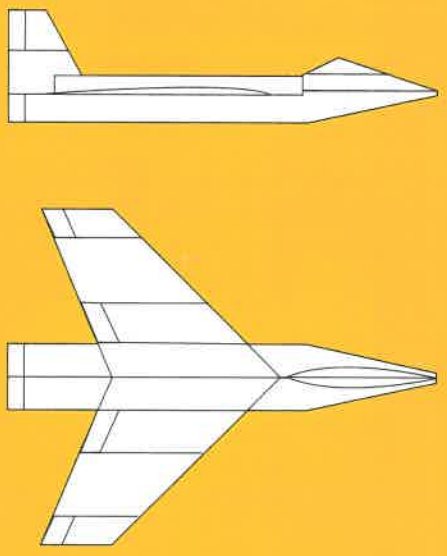
6 Gee Bee
(see p 24 for color suggestions).



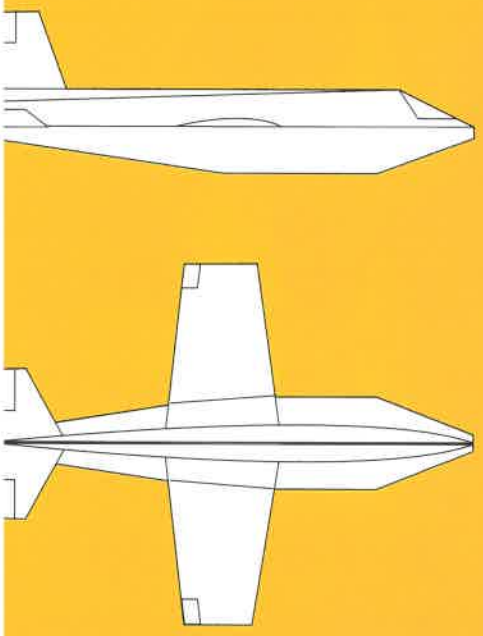
Thunderbolt
p 29 for color suggestions).



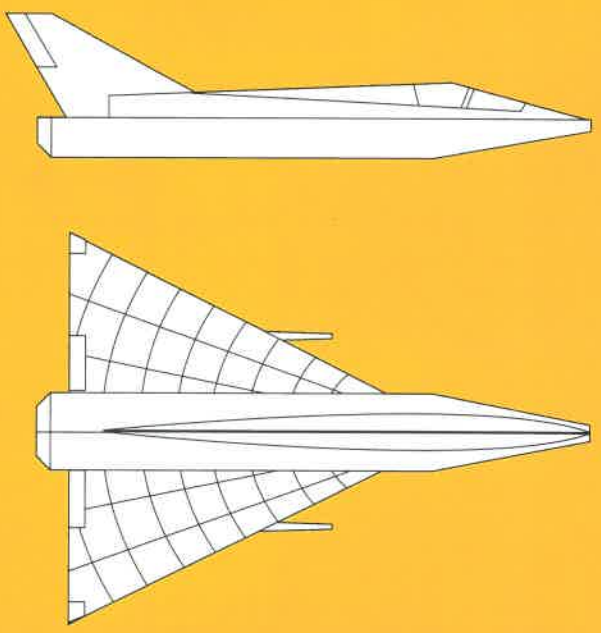
8 DH108 Swallow
(see p 33 for color suggestions).



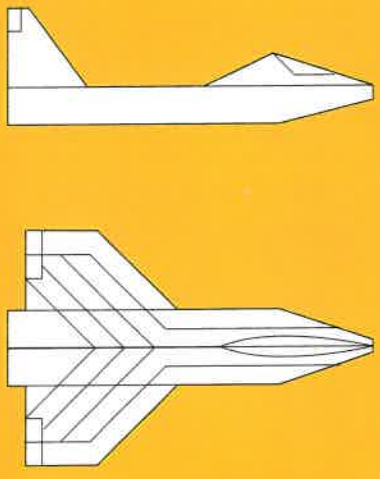
p 37 for color suggestions).



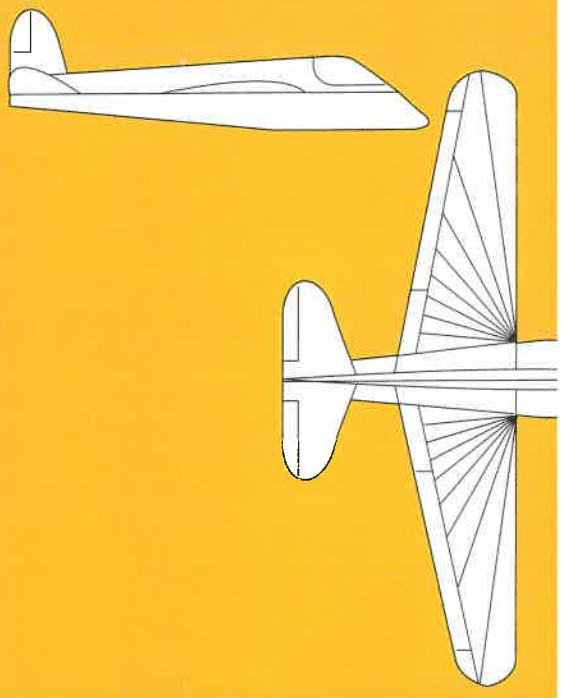
10 Mirage 2000
(see p 42 for color suggestions).



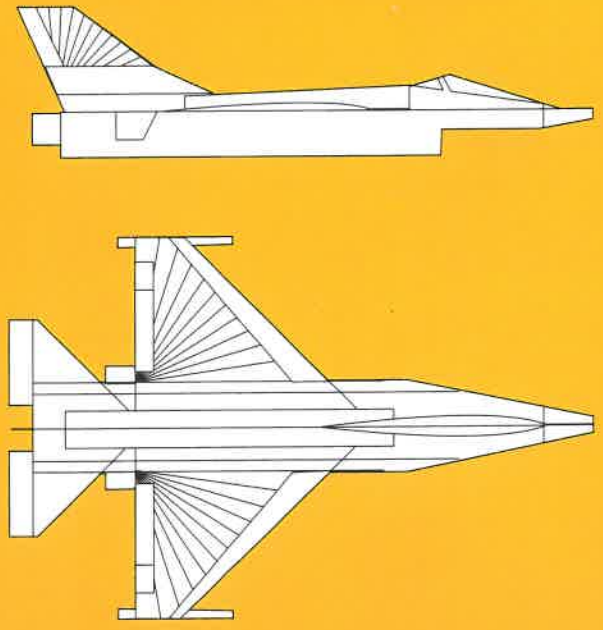
11 Lifting Body
(see p 46 for color suggestions).



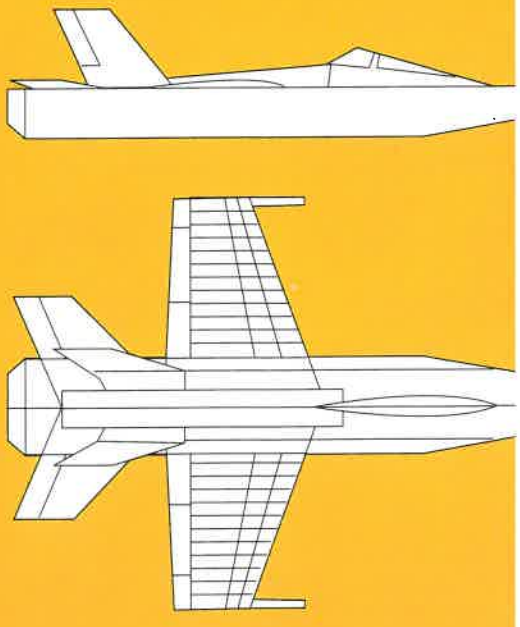
12 Glider
(see p 50 for color suggestions).



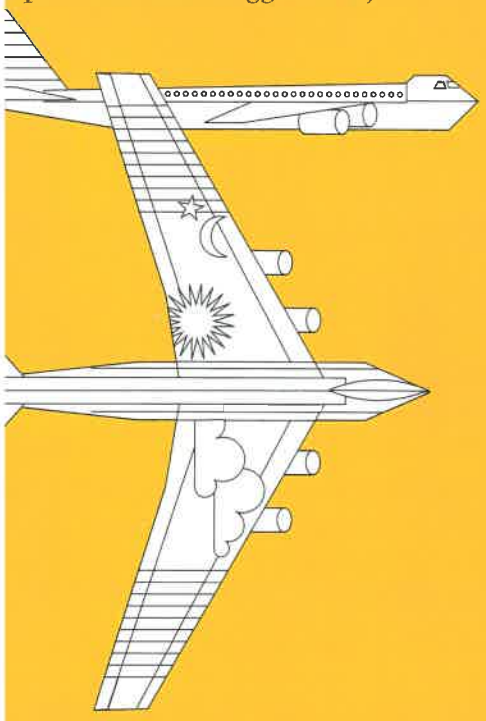
13 F16 Falcon
(see p 55 for color suggestions).



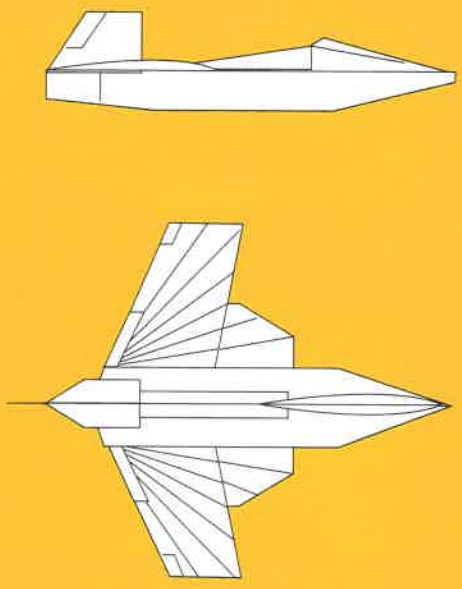
14 F18 Hornet
(see p 60 for color suggestions).



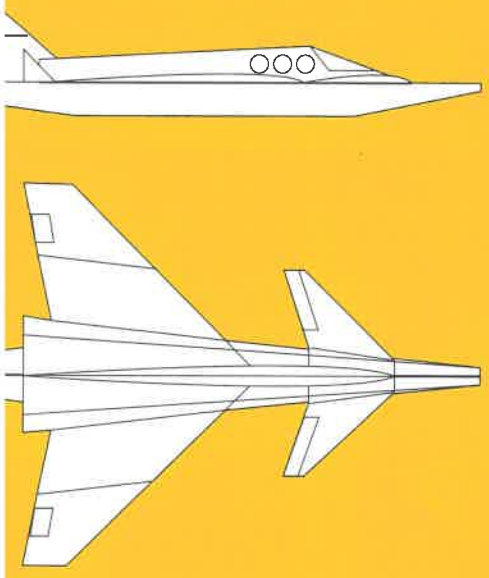
7 Jumbo Jet
e p 65 for color suggestions).



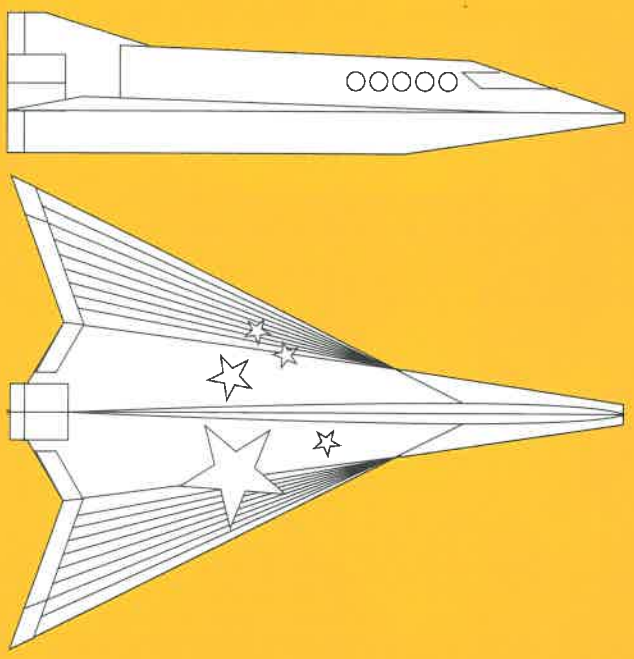
16 FSW Concept
(see p 71 for color suggestions).



T Concept
e p 76 for color suggestions).



18 TAV Concept
(see p 81 for color suggestions).



Glossary

Angle of attack The downward slant, from front to back, of a wing.

Angle of bank The raising of the outside wing and lowering of the inside wing during a turn.

Aspect ratio The length of a wing in relation to its width. The longer a wing, the higher its aspect ratio.

Attitude The direction an airplane is pointing in relation to the horizon (banking, yawing, or pitching).

Ballast Extra weight needed in the nose of an airplane to make the center of gravity coincide with the wings, which provide the lift.

Control surfaces Small surfaces that can be bent to alter the airflow and change an airplane's attitude — ailerons for bank, elevators for pitch, and rudders for yaw.

Dihedral angle Upward slanting of wings away from the fuselage. (Downward slanting is called anhedral.)

Drag The resistance of air on moving objects, slowing them down.

Fuselage The body of an airplane.

Leading edges The front edges of wings, tails, or other parts.

Lift The force of air pressure beneath the wings buoying up an airplane.

Maneuver Skilfully making an airplane fly in a desired direction — turn, climb, dive, stall, spin, or loop.

Pitch Nose up or nose down attitude.

Roll Rotation along the length of an airplane.

Spar The main internal frame that supports the wing.

Strakes Wedge-shaped extensions of the wing's lea (front) edges near the fuselage.

Trailing edges The back edges of wings, tails, or other parts.

Trim Making small adjustments to the control surfa to affect the attitude of an airplane.

Trim drag The drag (resistance) produced from ben control surfaces into the airflow.

Ventral fin A small stabilizer on each side of the fus underneath the tail.

Wing loading The amount of weight a given area o wing is required to lift.

Yaw Nose left or nose right attitude.

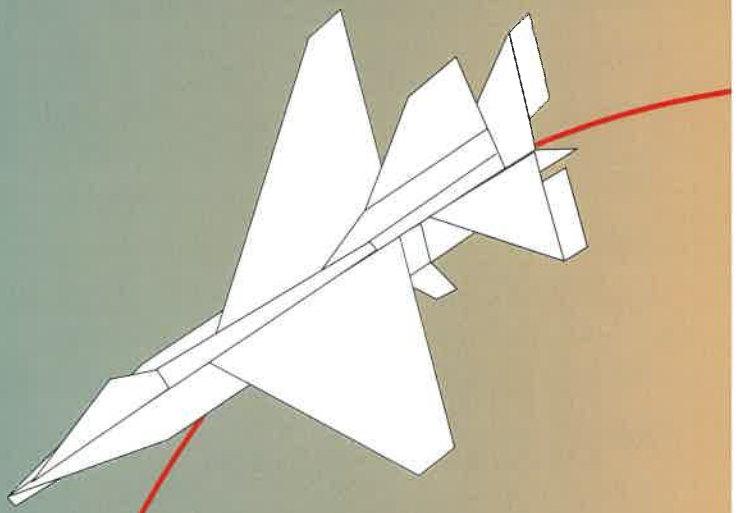
lying Tips

n't be discouraged if on first flight your paper plane "corkscrews" and crashes. Flying paper planes is a delicate balancing act. Only when rything works in harmony – wings, horizontal , vertical tail, and control surfaces – is cessful flight achieved. With each paper plane that you build, aim to improve the struction. When carefully made and trimmed, paper airplanes in this book are super flyers. remember, the performance of each airplane 'ers. Experimentation is necessary in order to ieve maximum performance. This is part of fun of flying paper planes.

ds that are not neat and crisp add drag to the plane. This will decrease glide performance. ppy folds can also result in twisted airplanes. ccurate gluing does not help matters. A twisted ne is sure to "corkscrew" badly (see p 7). The ortance of careful folds cannot be over phasized.

planes must be symmetrical – one side must just like the other. On both sides wing and izontal tail sizes, shapes, and thicknesses must the same. Also make sure that the control faces on one side are the same sizes and are t the same amount as on the other side.

ke sure that the dihedral (upward slanting of gs and tail) is adjusted correctly. In each ign, refer to the last step of construction for gestions. Sometimes experimentation with erent dihedral (or none at all) will be cessful. Dihedral povides stability, however, much dihedral has a destabilizing effect.



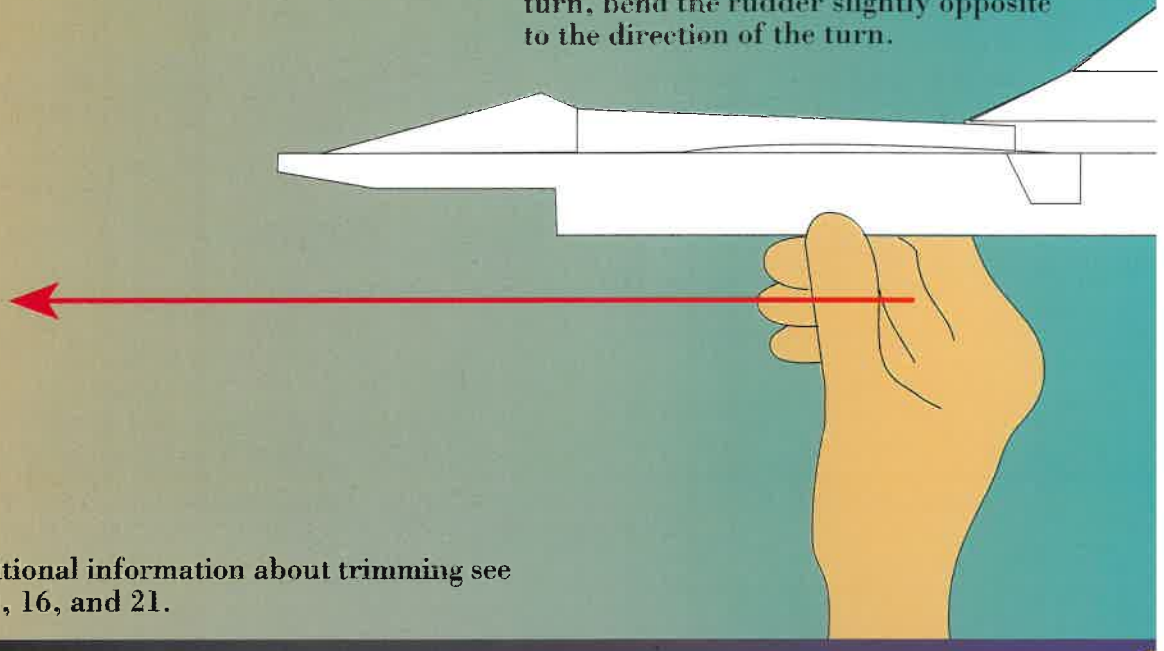
Some of the airplanes in this book have secondary control surfaces(flaps). Secondary control surfaces need special mention. If they are bent down slightly, lift is increased. If they are bent down 90° drag is greatly increased and the nose will pitch down. Additional up elevator is needed, increasing the angle of attack but also increasing drag. Trimmed in this way an airplane does not glide very far. In full-sized airplanes, this trim is good for landing. Experiment with different settings of the secondary control surfaces. Adjust carefully for best results.

Paper airplanes are not baseballs. They cannot thrown hard. To launch, hold the fuselage ligh between thumb and forefinger near the point where the plane balances. Throw with a firm forward motion keeping the nose level, pushing the airplane more than throwing it. With a bit practice you will discover just how hard each o the planes need to be thrown under different conditions.

Pitch trim Although the paper airplanes in t book are built to resemble powered aircraft, th are obviously all gliders. For thrust they must convert altitude into airspeed (see p 10). The pitching axis is very important in determining airspeed. Once properly trimmed, an airplane always fly at the same speed. If the airplane zoo toward the ground, bend the elevators up sligh to raise the nose. If more speed is needed, as in outdoor flight, less up elevator will produce the desired result.

Roll trim Providing the wings are not twiste the wings should remain more or less level in flig If one wing drops, bend the aileron on that win down slightly and up slightly on the other wing

Yaw trim If the plane still has a tendency t turn, bend the rudder slightly opposite to the direction of the turn.



For additional information about trimming see pages 13, 16, and 21.

urther Reading

yne, Walter. *The Leading Edge*. Stewart, ori & Chang, New York, 1986.

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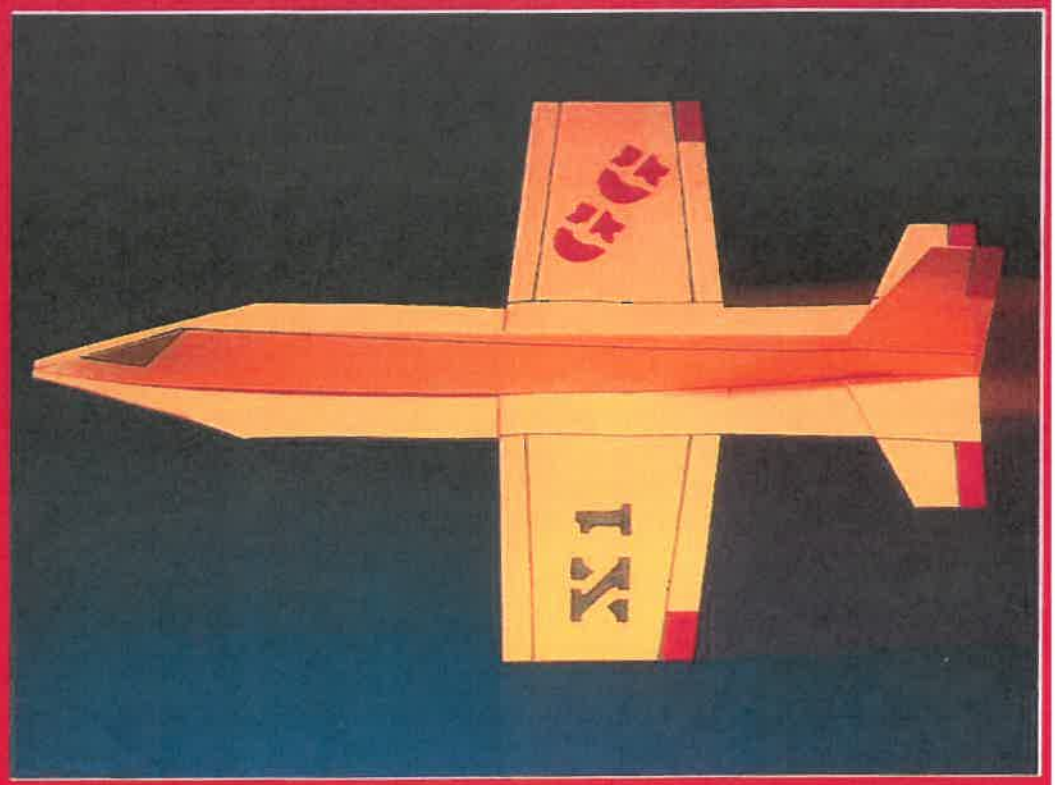

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